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APPLICATIONS: ELECTRODEPOSITION, ANODIZING, METAL SPRAYING, METAL FINISHES, METAL TREATMENTS

Vol. 1 No. 12 (new series)

DECEMBER, 1955

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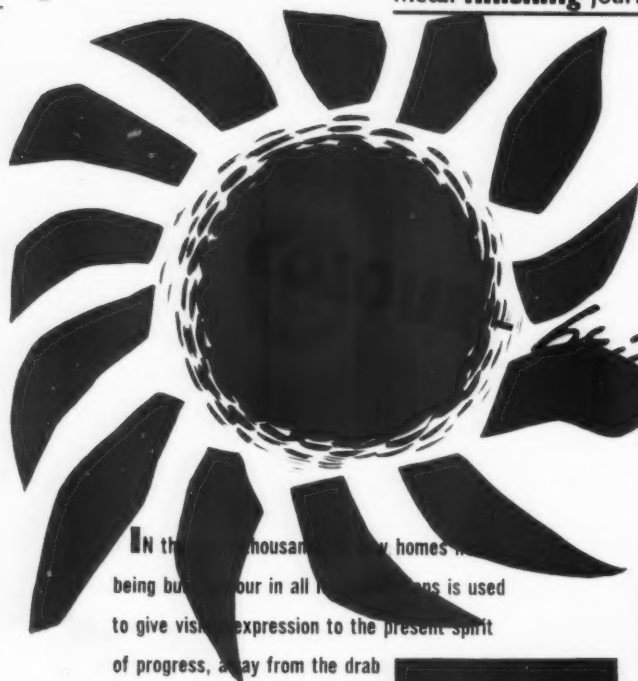
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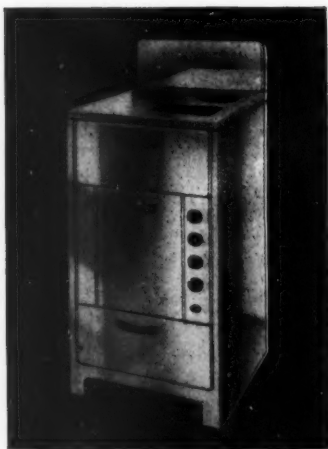
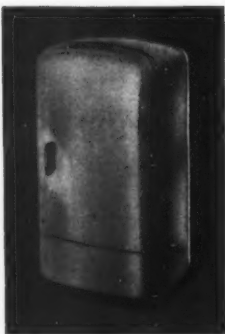
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DECEMBER, 1955



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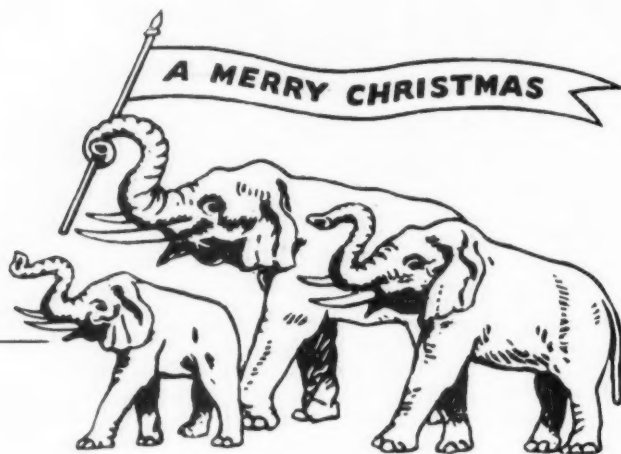
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THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING AND ALL METAL FINISHING PROCESSES.

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CHRISTMAS GREETINGS

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PEEDING THE SHINE

THE appeal of a highly polished reflective metal surface is nearly as old as Man himself and the methods of producing it remained unchanged for thousands of years. The use of abrasive powders of varying degrees of fineness and of burnishing and lapping tools was known to the Roman legions and for centuries before them.

In our present highly industrial community in spite of the passing of the years and of changes in taste, considerable effort is still expended on the production of highly polished finishes. Basically the method remains the same as in earlier years, the only advances having been in the formulation and control of abrasive materials and in the application of mechanical power in the form of a motor-driven buffing wheel as an aid to higher speed production.

Holding an article of complex design against a fast rotating buff and producing on it a high specular polish is a skilled job and a dirty one, and not unnaturally commands a high rate of pay. For the same reasons it is one to which the recruitment of labour fails to replace the wastage.

The increasing rates of production which are now commonly met with have been made possible by advances in the design and operation of fabricating equipment, and in order that polishing shall not constitute a bottle-neck in a high-speed production line attention has been turned to rendering the polishing process automatic. This has been achieved in many cases with considerable success where a sufficient quantity of articles of comparatively simple and symmetrical shape have to be processed, but the limitations imposed by requirements of a fast spinning buff make it difficult to design equipment to deal with more complicated and irregular forms. Similarly in jobbing plants and small works where the number of identical components handled at a time is not great, capital expenditure on automatic polishing equipment can hardly be justified.

This state of affairs has provoked a resurgence of interest in methods of polishing which do not involve the use of a high-speed wheel, and the two processes which are now coming in for the closest scrutiny in this category are barrel finishing and electropolishing.

Like manual finishing, barrel finishing languished for many years as an undeveloped process with considerable potentialities, and it is only in very recent years that developments have taken place as a result of which it can claim to be a precision engineering process. There can be little doubt that the high production speeds which can be achieved by the processing of components in bulk in suitably designed equipment using modern media will gain for the process wider adoption in the coming years.

Compared with barrel finishing, electropolishing is a very recent development, although the much publicized patent of Jacquet was taken out over twenty-five years ago. It is therefore an approximate contemporary of chromium plating, although the extent to which the two processes have received commercial application could hardly be more different. In contrast to the many hundreds of workshops and departments engaged in chromium plating, the number of companies making use of electrolytic polishing methods (on metals other than aluminium) can number barely a dozen.

This obvious reluctance to explore energetically the possibilities of a process which can clearly lend itself to high-speed production is not readily explained. The criticism has been levelled at it that the finish obtainable by its use does not compare for specular reflectivity with that produced by orthodox mechanical polishing, and it also has the disadvantage that it tends to reveal rather than conceal any metallurgical flaws on the surface. In spite of this, however, the work of one or two isolated pioneers, both in this country and overseas, has shown that a perfectly acceptable degree of polish can be achieved on suitable materials at very high speeds and with advantages in certain other properties such as tarnish resistance.

Talking Points

by "PLATELAYER"

TOPICAL COMMENT
FROM THE MAIN
LINES AND SIDE
LINES OF METAL
FINISHING

SCIENCE FOR BEGINNERS

DURING the course of a private meeting of the Parliamentary and Scientific Committee when the subject of the popularization of scientific ideas was discussed recently, the Duke of Edinburgh expressed the view that it was unreasonable to expect scientists to express complicated and difficult concepts in language that the ordinary person could understand.

It is interesting to observe that the Duke should have taken a stand which differs widely from that held in Government and administrative circles generally. As most of the nation's leaders are not scientifically trained people, a major difficulty of the scientist is to secure recognition of a concept by people who are not really qualified to understand it, let alone assess its value. In an attempt to make himself comprehensible the scientist may be led to dangerous over-simplifications which can bring his ideas into disrepute. Yet very often he has no real alternative.

If the adviser is of a sufficiently high standing, as was Einstein when he recommended Roosevelt to proceed with the development of atomic energy during the war, his conclusions are taken on trust and there is no need for him to go into details. The smaller scientific fry, however, have a hard time making themselves intelligible to their uninitiated superiors, with consequent ill-effect on the rate of technological development.

THE COST OF VACILLATION

THERE was a reference in the House of Lords recently to a Brigadier who used to nail files relating to matters on which he was unable, or unwilling, to give a decision to the floor under the carpet in his office, where they were found on his retirement after a long and honorable career. Delay in giving decisions, or indeed, in implementing decisions on which agreement has been reached, is a vice which is not confined to Government circles by any means. The economic consequences of such delays are not easily calculable, but they must be considerable.

It can be taken as a fairly general rule that most decisions of any consequence in industry concern changes which will result in improvements leading to economies of some kind. Each day that passes before the proposals are put into effect must therefore represent a loss, the extent

of which depends on the magnitude of the project. It would, no doubt, be a sobering thought to an executive if he paused to reflect on the fact that a file staying on his desk awaiting signature might be costing his organisation thousands of pounds a day.

Everyone knows that time is money on the shop floor, but is it as well known that it is even more money on the manager's desk?

AN ITCH FOR MONEY

DERMATITIC conditions are still a hazard in the finishing industries, although with improved preventative measures and better hygienic conditions they are less common or disabling than they were at one time.

In a recent article, an industrial medical officer, however, goes so far as to say that in many cases industrial dermatitis occurs in "people with an inadequate personality for whom industrial disease provides financial compensation and gives a measure of security, which, as they approach middle age, is lacking in their lives. Treatment is usually temporary and their condition will frequently clear up if financial compensation is adjusted to their satisfaction."

This is something that those responsible for industrial compensation claims have sometimes suspected, but the law of course, takes no cognisance of the "compensation syndrome" as a causative factor of dermatitis when the disease is of industrial origin.

If the doctor is right in his remarks (as he may well be) the inevitable conclusion is that financially secure employees will be less likely to develop industrial dermatitis than those in more precarious economic circumstances. Also, crossing the patient's palm with silver is going to be more effective than applying an ointment.

The reasons for the immunity of some people and the undue susceptibility of others to industrial dermatitis have yet to be accounted for; certain workers can handle chromium compounds for years with scant attention to safety precautions, while there are cases on record of clerical staff who have contracted the condition in the course of work which has involved them entering chromium plating departments on isolated occasions.

Dermatitis costs industry enormous sums annually, and by its very nature its investigation presents great difficulties to the research worker.

The Successful Application of ELECTROLYTIC POLISHING in Industry

By R. MONDON*

In the current issue of SHEET METAL INDUSTRIES the author reviews a number of industrial applications of electrolytic polishing which are being successfully employed in France. While much of what he has written relates to the use of the process for engineering purposes, he also makes many points of particular interest to the metal finishing industry which are abstracted here.

Introduction

THE discovery of the principle of electrolytic polishing by P. A. Jacquet is now twenty-five years old and its importance is no longer denied in metallurgical laboratories, in view of the numerous successes attained by the use of this technique of polishing in scientific metallurgy; the same cannot be said of its advancement in the domain of industrial application.

At the present time, despite the amount of work done on the adaptation of electrolytic polishing to industrial uses, the difficulties encountered have been so great that in many quarters the practicability of its industrial application is still seriously doubted.

While prospective users have seen in this process a means of abolishing or supplanting mechanical polishing methods, experience has shown that this is impracticable, at least until metallic materials are commercially available of considerably higher metallurgical qualities than has hitherto been the case.

It has to be borne in mind that electrolytic polishing is less universally useful than any other polishing technique, and its results are not generally comparable with those obtained by mechanical methods. These last effect a viscous spreading of the superficial layers of the material, levelling the protuberances and filling in the depressions; to some extent, they mask surface defects, rather than reveal them. The result is a modification of the surface structure, with formation of a surface "skin"—also sometimes called the "Beilby layer." This microcrystalline skin (according to the latest researches on its constitution) also exhibits chemical and physical modifications compared with the underlying metal. These are due to the materials used in polishing and the high temperatures developed in the process.

This gives the general conception of mechanical

polishing, operating by material flow, by spreading of the superficial layers. It is fairly difficult to perform, thus more or less costly, but is always practicable.

Electrolytic polishing is an entirely different process. It acts by selective solution of the protuberances, causing a general levelling of the surface, which is the more effective, the greater the homogeneity of the material structure.

The best results are obtained with a metal the rate of solution of which is the same in all parts, after removal of the protuberances.

In this regard, the structure of the metal is the fundamental factor. If there are present structural irregularities, inclusions, cracks, or other flaws, electrolytic polishing will infallibly bring them to light.

It is easy to see, therefore, that in decorative uses, and with the materials at present available, electrolytic polishing can never supplant the mechanical processes.

However, in the case of articles of complicated shape, where mechanical treatment would be exceedingly difficult and costly, if not completely impossible, electrolytic polishing may be used to advantage. In the case of such articles, furthermore, surface flaws, if not of excessive extent, will merge into the general background, and not be too obvious. This refers, however, only to special cases, and the two techniques are, thus, complementary rather than competitive.

The case is quite different in regard to the properties of metallic surfaces which particularly influence their behaviour in the presence of friction or abrasion, as well as fatigue strength and corrosion resistance.

Electrolytic solution of surface layers disturbed and modified by different machining (*i.e.*, cutting) operations and heat treatments, produces new characteristics which affect all subsequent shaping and forming operations, particularly in mechanical engineering practice.

*Technical Director of S. A. Jacquet-Hispano Suiza, France.

The article from which the present abstract is taken is devoted to a study of these properties and characteristics, and the possibilities of application arising out of them.

Fatigue

The principal controversies centring on the possibility of using electrolytic polishing for surface finishing mechanical parts are raised by its usually unfavourable influence on the results of laboratory fatigue tests.

Experience has shown, however, that the very great number of mechanical parts which have undergone this treatment have not suffered in any way—rather the reverse.

It appears essential, therefore, to examine the more important research results available on this question, and endeavour to draw the right conclusions from them.

Most research workers who have used electrolytic polishing as the final stage in the preparation of their fatigue samples, have found that this method, far from improving the behaviour of the metal (steel), has, in fact, clearly reduced the fatigue strength of the material.

In some cases, however, an improvement has been perceptible. Thus, in an alternating torsion test to determine the fatigue limit of a nickel-chrome-molybdenum steel, heat treated to 165 kg. per sq. mm. (104.76 tons per sq. in.) it has been found (1) that the fatigue limit increased by 34 per cent after electrolytic polishing of the ground surface of the sample.

The same steel treated to a slightly lower tensile strength, on the contrary, showed a more or less considerable loss of fatigue strength after electrolytic polishing.

Chrome-molybdenum steels of different qualities and hard and semi-hard carbon steels, under alternating torsion, showed in all cases a lower fatigue limit after electrolytic polishing.

It was concluded at the time that the results apparently depended simultaneously on the quality of the steel, the heat treatment applied, the number and form of distribution of superficial inclusions, as well as the amount of stress introduced by machining.

More recently, Hempel(2) has published the results of a detailed investigation into the fatigue behaviour of different steels under varying conditions of surface stress produced by the working of the sample, in the alternating bend test.

Hempel found:—

(a) That mechanical polishing of 7.52 mm. (0.27 in.) diameter test-bars set up compression stresses of the order of 40 to 60 kg. per sq. mm. (25½ to 38 tons per sq. in.) localized at a depth between 2/100 to 5/100 mm. (0.0008 to 0.002 in.) below the surface.

(b) That these stresses could be relieved by annealing for 2 hours at 500° C. in a vacuum furnace.

(c) That this heat treatment caused a drop in the fatigue limit, for instance, from 66 to 64 kg. per sq. mm. (42 to 40½ tons per sq. in.) for a chrome-vanadium steel, and from 53 to 46 kg. per sq. mm. (33½ to 29½ tons per sq. in.) for an ordinary carbon steel.

(d) That electrolytic polishing (in an acetic-perchloric-acid bath) similarly lowered the fatigue limit, by an amount depending both on the quality of the steel and the nature of the heat treatment applied.

As these results show, the unfavourable effect of electrolytic polishing is closely comparable with that of a stress-relieving anneal, *i.e.*, it similarly contributes to relief of the compression stresses promoting a higher fatigue limit.

At the Régie Nationale des Usines Renault, P. Michel (3) found that electrolytic polishing (in an acetic-perchloric bath) practically did not affect the fatigue limit in rotary bending, of a nickel-chrome steel, heat treated to 85 kg. per sq. mm. (54 tons per sq. in.) and previously polished with emery cloth.

A. T. Steer, J. K. Wilson and O. Wright, of D. Napier and Son Ltd., recently published(4) the results of their researches on the use of electrolytic polishing as a substitute for machining in the finishing of engine components.

These authors have endeavoured to determine the influence on fatigue strength of the removal of an appreciable layer of metal by electrolytic polishing.

The steels chosen were grades S.97 and EN 25, of the nickel-chrome-molybdenum type, treated to the usual values for use in engine connecting rods. The test bars had a thickness of 25/100 mm. (0.01 in.) on the diameter, removed by solution, being reduced from 6.93 mm. (0.273 in.) after grinding, to 6.68 mm. (0.263 in.) after electrolytic polishing.

The tests were made with rotating bending and for the two steels S.97 and EN 15 considered, resulted in a reduction of the fatigue limit by 15 per cent and 18.3 per cent respectively.

The authors point out the significant uniformity of the results obtained under the same loads, on test-bars of the same steel, scattering being practically nil!

On the other hand, the explanation which they give for this lowering of the fatigue limit does not appear very convincing, *i.e.*, that multiple cracks develop by notch effect from the small holes generally left after the removal of superficial inclusions by the action of the electrolytic polishing.

Apart from the fact that this explanation is inconsistent with the observed absence of scattering in the results, it can be assumed that, except in

special cases of faults in the steel, the small depth of these holes compared with their diameter causes them to become perfectly polished, and it is difficult to see how they can play any important part in the formation of fatigue cracks.

The authors have also found—and this is the really important result of their labours—that a surface treatment as mild as “vapour honing” completely restores the fatigue strength of the electrolytically polished test bars. Since it appears obvious that this treatment will primarily have the effect of setting up superficial compression stresses, it would seem that it is the relief of these stresses which is the prime cause of the loss of fatigue strength by electrolytic polishing.

The results of all relevant researches on this question may finally be summarized as follows:—

1. The fatigue strength of a particular metal is not solely determined by the microgeometry of its surface finish: the stresses set up in the superficial layers by the operations of mechanical finishing—grinding, lapping, polishing, superfinishing—are probably of cardinal importance.

2. In principle, superficial compression stresses influence the fatigue behaviour favourably, while corresponding tensile stresses have the opposite effect. In the case of laboratory samples of simple form, the mechanical polishing to which they are subjected usually sets up compression stresses. It will be appreciated that removal of the superficial layers in which these stresses are concentrated, by solution, will cause them to vanish and thus more or less depress the value of the fatigue limit.

3. Such superficial stresses are not always compressive, and the important researches of Almen in the laboratories of General Motors Co.⁽⁵⁾ have demonstrated that current grinding practice leads rather to the development of tensile than of compression stresses.

4. The observation that the scattering of results when plotting continuous fatigue curves is considerably less with electrolytically polished samples than with those polished mechanically, leads to the conclusion that the fatigue limit obtained for electrolytically polished samples is the *true value* of the characteristic fatigue strength of the particular metal and its metallurgical state; while the values obtained for mechanically polished samples are falsified by the disturbance of the surface structure.

5. In the case of the actual mechanical parts or components, it is in practice nearly impossible to obtain the same high surface finish in all parts; this results in an irregular distribution of the surface stresses, the intensity and even the type of which may vary over the whole extent of the piece.

Suitably executed electrolytic polishing will tend to homogenize the surface characteristics by the

elimination of machining stresses and particular chemical or structural irregularities such as decarburization.

As a matter of fact, the revealing of flaws otherwise masked by the action of mechanical polishing, should facilitate the elimination of faulty pieces.

6. In certain cases, of parts required to withstand particularly severe dynamic loads, it will always be advantageous to reduce the irregularly distributed surface stresses to zero by suitable electrolytic treatment, then applying some usual method of producing a state of *uniform* compression stress in the surface layers, such as shot peening, vapour blast, or vapour honing.

Corrosion

An improvement in corrosion resistance is usually found to follow electrolytic polishing, equally in regard to ordinary, atmospheric corrosion, or in conditions of high or low humidity.

In the case of stainless steels, the remarkable degree of passivation obtained by electrolytic polishing has, for instance, enabled improvements to be introduced in the manufacture of certain types of Geiger counters, which can now be given properties otherwise unobtainable by the usual methods of pickling and chemical passivation⁽⁶⁾.

Electrolytic polishing of steam-turbine blades and pump elements, in cast stainless steel, has considerably improved their behaviour in service.

In regard to dry corrosion, the improved behaviour of electrical resistance wires after electrolytic polishing may be cited as an example.

In the case of high-temperature alloy sheets, such as Nimonic 75, as used in turbo jets and gas turbines, a considerable loss of chromium from the superficial layers of the metal, involving a loss of resistance to dry oxidation (scaling) has been observed⁽⁷⁾. Electrolytic polishing, by removing these layers, restores the normal properties of the material.

A recent paper by J. Heyes⁽⁸⁾ makes prominent mention of the improved resistance to fatigue corrosion of electrolytically polished gearwheels. The phenomenon of pitting which causes much trouble in highly loaded gears, appears only at far higher loading values in electrolytically polished than in ordinary gears.

Preparation of Surfaces for Electroplating

The electrolytic polishing of steel before nickel-plating is used in the United States in the manufacture of automobile bumpers. In France, the method has been particularly used as a preparation for hard chroming.

Laboratory tests have shown that electrolytic polishing of the foundation metal gives the

(Continued in page 538)

PRODUCTIVITY IN PLATING

Birmingham Production Engineers discuss Economics of Metal Finishing

A MEETING of the Birmingham Section of the Institution of Production Engineers was held at the James Watt Memorial Institute on November 16 at which three papers were presented under the general head of "Practical and Economic Aspects of Modern Metal Finishing." These papers were: "Choice of Electrodeposits and Methods of Producing them," by A. F. Brockington; "Some Practical and Economic Aspects of Production Plating," by D. N. Layton; and "Recent Developments in Electroplating," by R. Fyfe.

Nearly forty members braved the foggy weather in order to hear these three speakers. After the authors had presented their papers, a lively and interesting discussion took place which continued in small groups for quite a while after the Chairman had declared the meeting officially closed and he and many of the audience had gone home.

In his paper, Mr. Brockington described briefly the main applications for which most electrodeposits were used and the types of solution from which they were deposited. He outlined the conditions under which zinc and cadmium were most suitable for corrosion protection of steel; the use of nickel for corrosion resistance and building-up in engineering applications; and the use of chromium for producing very hard deposits, and for preventing tarnishing of nickel used in decorative and protective applications such as car components. In addition, he pointed out the main considerations to be borne in mind in designing components for electroplating and the care which should be taken in specifying thickness of deposits and controlling the quality of the products. He finished by showing a most interesting set of slides illustrating the wide diversity of plants used in electroplating from very simple manually loaded vats to large, completely automatic plants.

Dr. Layton, in his talk, pointed out that the ultimate aim of any production unit was to achieve the best quality at the lowest cost. Not only was it necessary for the quality of the product in itself to be the best obtainable at the price, but the service given by the finishing shop—whether it was a department attached to a manufacturing unit or an outplater working under contract to the manufacturer—also had to be the best possible. It was, therefore, the task

of everyone concerned with a production metal-finishing shop, whether he be works manager, planner, foreman or technical control chemist, to work towards this aim.

At first sight the plater might appear to be in an easier financial position than the manufacturer in that he had very little capital tied up in raw materials and labour costs in "work in hand" as compared with the manufacturer. On the other hand, he had the responsibility of processing other people's property which as a result of work already carried out on it was, when it reached the plater, worth many times more to the manufacturer than the mere cost of the raw material.

The cost of plating articles could be regarded as made up of two components:—

- (1) A direct cost which was the same for each article regardless of the total number plated and which included the cost of the metal deposited on the article, labour involved in polishing and plating, and the overheads appropriate to these items;
- (2) The indirect cost which was the cost of running the factory and the processes irrespective of the number of articles and which was apportioned to the work processed according to the amount of time and space they occupied in the factory.

The overall reduction of the cost of metal finishing involved reducing both these components. The first component could be reduced by care in jigging and plating (so as to avoid waste of metal by uneven distribution on the articles and excessive drag-out of solution on removal from the vat) and also by reducing polishing and other labour costs by suitable design and layout of the processes used. The second component of cost was reduced by increasing the number of articles plated per unit time per unit area of the vat. This, though simple in principle, generally involved a number of practical difficulties.

Rejects always had to be kept to a low percentage because an article which had been rejected and replated might eventually cost at least three times the cost of plating it correctly the first time. In a number of cases, manufacturers did not bother to reclaim rejects from their finishing shops since it was cheaper to scrap the

(Continued in page 526)

HYDROGEN PERMEABILITY of Steel and its Relation to ENAMELLABILITY

by YNGVE LINDBLOM and S. E. DAHLGREN

A Paper presented to the 2nd International Enamelling Congress, Leamington Spa, October, 1955

Introduction

It has long been known that hydrogen plays an important role in the enamelling process. Investigations at the National Bureau of Standards⁽¹⁾ have verified in a refined manner the correctness of the opinion, earlier forwarded by several authors, that hydrogen mainly arises from the reaction between the steel base and the water combined in the enamel frits. It is unavoidable that commercial frits contain a certain amount of combined water. Eleven investigated frits had a water content of 0.12 to 0.31 per cent. Therefore the original source of the hydrogen cannot be eliminated. It has been pointed out that some frits are sensitive to too dry an atmosphere in the enamelling furnace⁽²⁾. For best enamelling results a dew point of 5 to 10° C. has been recommended. Similar experience arises from the ceramic field. It is therefore possible that a certain water content in the frits may be beneficial in some other respects. The easiest way for the enameller to deal with the problem is—as usual—the steel. Its properties are of great importance in this connexion. The greater the amount of the produced hydrogen that manages to diffuse into the steel during the enamelling process, the more pronounced are fishscaling and reboiling, and the worse is the adherence. This would actually mean—the tighter the steel structure the better the enameability.

The purpose of this paper has been to investigate if there are any relations between hydrogen permeability in the steel, measured at about 40° C., and its gas content, metallographical structure, and analysis and how this corresponds to the enamelling results. In the measurement of the hydrogen permeability, there are several connexions with pickling problems.

The Influence of Inhibitors, Surface Conditions, and Iron Base on Hydrogen Diffusion

The question of the hydrogen pick-up in iron sheets has been thoroughly investigated in relation to the pickling process. Thus there is available

a lot of knowledge about the hydrogen penetration of steel, useful for the enameller. When pickling one wants to avoid attack of the acid on the metallic iron, the evolution of hydrogen, and the penetration by diffusion of hydrogen. This is at least partly achieved by adding pickling inhibitors to the pickling bath. The inhibitors create a change of the surface of the metal so that the hydrogen penetration through the surface layer is made more difficult. There is a great variety of inhibitors with different characteristics. Especially interesting is the extent to which the individual inhibitors inhibit the evolution of hydrogen and the extent to which they inhibit the penetration of hydrogen by diffusion. The individual inhibitors do not affect these two mechanisms in the same manner. If arsenic is added to a pickling bath, a deposit of arsenic is formed on the iron surface and the evolution of hydrogen is inhibited or reduced. But as the hydrogen overvoltage on arsenic is higher than on iron, the hydrogen penetration by diffusion is increased by the presence of arsenic. Therefore pickling baths must be as free from arsenic as possible.

The most widely used inhibitors are organic substances. They generally prevent both hydrogen evolution and hydrogen penetration. They form an adsorbed layer on the surface of the iron, which retards the diffusion of the pickling reagents to the iron, resulting in a high electric resistance. This inhibits the evolution of hydrogen. The possibilities for substitution of hydrogen in the layer may furthermore have a catalytic effect on the formation of hydrogen molecules from hydrogen atoms, and so the penetration of hydrogen by diffusion is also made more difficult, since hydrogen diffuses in the iron as protons.

From all this it has become apparent that the surface conditions are of the utmost importance for the pickling reactions and the hydrogen penetration by diffusion. But surface conditions are not only governed by the surrounding medium but also by the properties of the iron. It is known

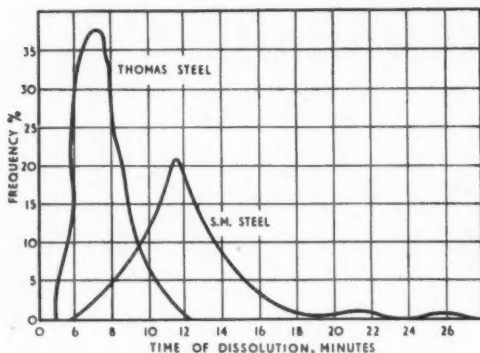
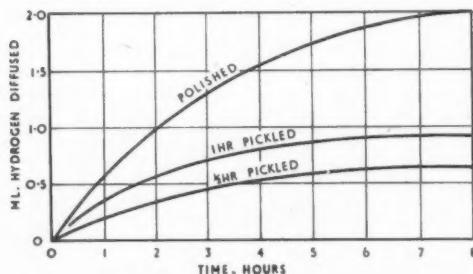


Fig. 1 (above)—Velocity of dissolution of chips for analysis from Thomas Steel and S-M steel respectively. (Daeves, Schulz and Stenkhoff, Stahl und Eisen, 1932, 1937).

Fig. 2 (below)—Influence of previous roughening-up of surface by pickling on hydrogen-diffusivity. (W. Baukloh and G. Zimmermann, Arch. Eisenhüttenwesen, 9 (1935/36), 9, p. 459).



that cold-working considerably accelerates the dissolution of iron in acids. Different kinds of heat treatment give different dissolution rates. Interesting is the difference in dissolution rate between basic Bessemer steel (Thomas steel) and open-hearth steel (Siemens-Martin steel). From Fig. 1 it can be seen that the dissolution rate of basic Bessemer steel is greater and much less scattered than that of open-hearth steel. This difference may be due to several factors of which the higher P- and N-contents and the lower Cu-

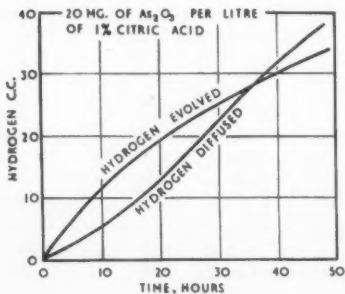


Fig. 4 (left)—Effect of traces of arsenic trioxide. (T. N. Morris, J. Soc. Chem. Ind., 1935, 54 11T).

Fig. 5 (right)—Influence of $HgCl_2$ on hydrogen diffusion (A. A. W. Aten, Rec. Trav. Chim., 1930, 49, 641; 1931, 50, 943).

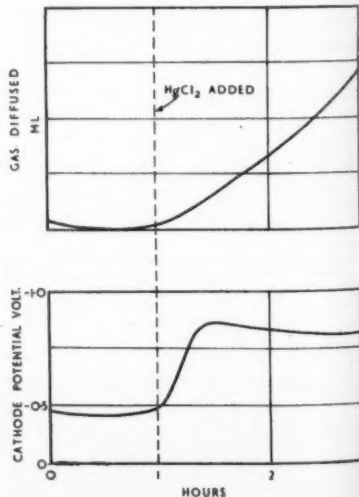
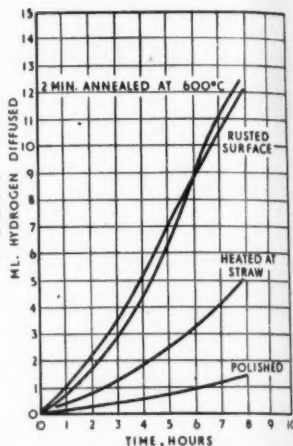


Fig. 3 (right)—Influence of the oxidation of the surface on hydrogen diffusivity (W. Baukloh and G. Zimmermann).



content of basic Bessemer steel are the most important. The mechanisms are quite complicated and cannot be discussed here.

One of the most important factors determining the hydrogen penetration by diffusion is the degree of roughness of the iron surface. From Fig. 2 it is seen that less hydrogen penetrates as roughness increases. The influence of roughness on the hydrogen diffusivity is not the same for atomic and molecular hydrogen as is shown in Table I.

The migrating velocity for hydrogen in iron is quite considerable even at low temperatures because hydrogen diffuses as protons. The diffusion takes place through the lattice, since the diffusion rate is the same whether the material is poly-

TABLE I.

Diffusion of Hydrogen as Function of the Roughness of the Iron Surface.

Variation of permeability by:	Roughening of the intake surface.	Smoothing (poisoning)	Roughening of the exit surface.	Smoothing (poisoning)
For atomic H For molecular H	decreased increased	increased decreased	increased increased	decreased decreased

after J. D. Fast

crystalline or mono-crystalline. It has been shown that the presence of hydrogen in iron is accompanied by a slight but measurable dilatation of the lattice.

Among the factors determining the hydrogen intake through an iron surface a few more may be mentioned having importance for the experimental methods. Oxide layers on iron increase the hydrogen diffusion. This influence is demonstrated in Fig. 3. Especially has it been found that deposits of As_2O_3 increase the hydrogen adsorption. The influence of arsenic has been mentioned

than globular cementite, as is shown in Fig. 6, probably because hydrogen diffuses more easily in ferrite than in cementite. In Table II is shown the remarkable effect of titanium on the hydrogen adsorption, which perhaps is one reason for the favourable effect of titanium on subsequent enamelling. This favourable effect has been attributed to the nitride—and carbide-forming properties of titanium. Vanadium is said to have a similar effect.

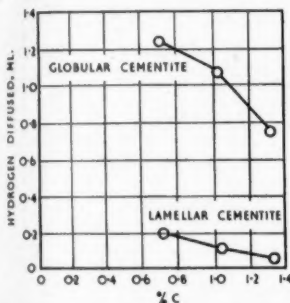
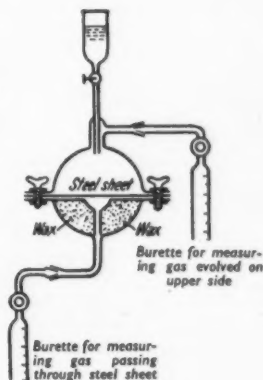


Fig. 6 (left)—Hydrogen diffusion as a function of C-content of sheet. H_2SO_4 387 g/l. sheet thickness 1.2 mm. Temperature $40^\circ C$. (Bardenheuer and Thanheiser).

Fig. 7 (right)—Apparatus for the separate collection of hydrogen developed on the top side of the steel plate by acid and hydrogen diffused through the metal to the bottom side of the plate (T. N. Morris).



before and further proof of this influence is supplied by Fig. 4. Mercury has a similar effect which is shown in Fig. 5. Besides causing a change of cathode potential the deposition of mercury on iron also increases the hydrogen overvoltage.

Investigations into the influence of the iron base on hydrogen diffusion have shown that hydrogen diffusion is dependent on the carbon content and on the form in which carbon is present. Lamellar cementite gives slower diffusion

Experimental Determination of Hydrogen Adsorption

It has been found that the direct determination of hydrogen adsorption in iron is difficult and not very exact in the results. Therefore it has been tried to estimate the adsorption by measuring the hydrogen penetration by diffusion. An apparatus for this purpose is shown in Fig. 7. An iron sheet is clamped with a gastight joint

TABLE II.

*Relation between Type of Steel and Hydrogen Adsorbed **

Steel material	ml adsorbed hydrogen per cm^2 surface	Spangle effect after galvanizing
Ti-treated steel ... ..	.0046	large spangles
Open-hearth steel ... ..	.0124	" "
Open-hearth steel ... ..	.124	small "
Low-carbon steel ... ..	.162	" "

* after H. Bablik

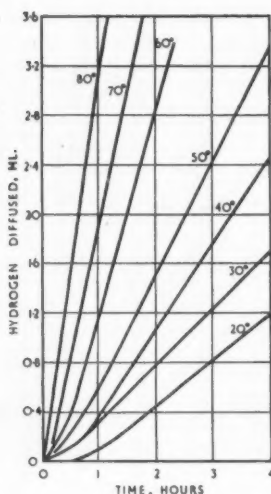


Fig. 8 (left)—Hydrogen diffusion as a function of temperature. 387 gm. per litre. H_2SO_4 , 1.2 mm. sheet, .594 sq. dm. (Bardenheuer and Thanheiser).

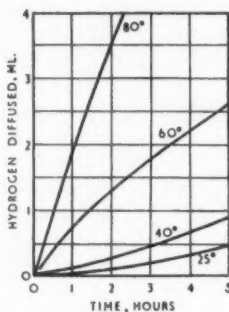


Fig. 9 (above)—Hydrogen diffusion as a function of temperature, with hydrochloric acid equivalent to sulphuric acid containing 297 gm. per litre H_2SO_4 , 1.2 mm., .594 sq. dm. (Bardenheuer and Thanheiser).

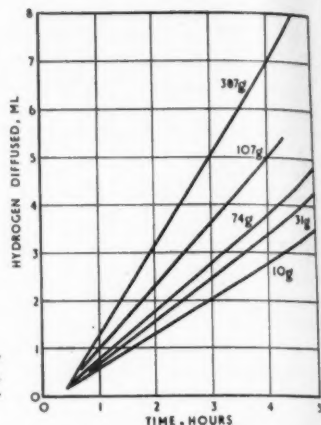


Fig. 10 (above) Hydrogen diffusion as a function of H_2SO_4 concentration, 60° C., 1.2 mm. sheet (Bardenheuer and Thanheiser).

between two glass hemispheres and brought into contact with acid on one side. The penetrating hydrogen is measured volumetrically on the other side of the sheet. From such experiments it has been discovered that more hydrogen diffuses when pickling in sulphuric acid than when pickling in hydrochloric acid. Figs. 8-11 show how the amount of diffused hydrogen varies with temperature, kind of acid, and concentration of acid. Of interest is that the apparatus mentioned makes it possible to determine the quantity of diffused hydrogen in relation to the quantity of totally evolved hydrogen as is shown in Table III. Apparently less of the evolved hydrogen diffuses through the sheet when pickling with hydrochloric acid than with sulphuric acid.

A further development of the measurement of

Fig. 11 (right)—Hydrogen diffusion using 387 gm. per litre H_2SO_4 as compared with HCl equivalent to 297 gm. per litre H_2SO_4 (Bardenheuer and Thanheiser).

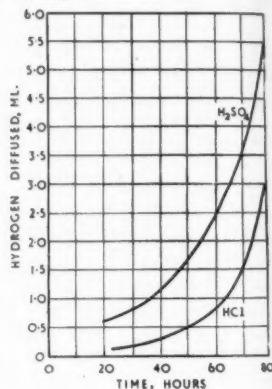


TABLE III. *

387 gm. per litre H_2SO_4 1.2 mm Sheet

Temperature °C.	Hydrogen evolved ml per dm ² per hr	Hydrogen diffused ml per dm ² per hr	$\frac{H \text{ diffused}}{H \text{ evolved}}$ per cent
50	62.4	1.55	2.59
60	131.9	2.74	2.08
70	209.7	3.55	1.69

Hydrochloric Acid Equivalent to 297 gm. per litre H_2SO_4 1.2 mm Sheet

Temperature °C.	Hydrogen evolved ml per dm ² per hr	Hydrogen diffused ml per dm ² per hr	$\frac{H \text{ diffused}}{H \text{ evolved}}$ per cent
25	45.3	.17	.37
40	135.6	.34	.25
60	818.0	.76	.09

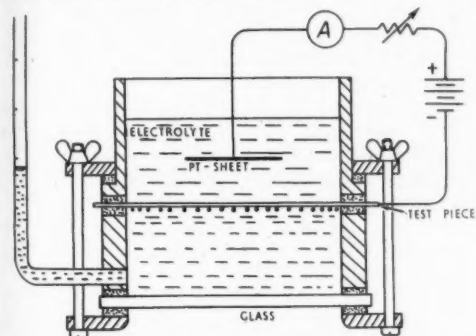
* after Bardenheuer and Thanheiser

TABLE IV. *

N. H ₂ SO ₄ 19° C. 0.006 amp. per sq. cm. 15 minutes		
Admixture	Extracted hydrogen, ml	
	With admixture	Without admixture
250 mg As/l... ..	6.19	.47
2 mg S/ml (CS ₂)	4.55	.44
20 mg Se/l	8.02	.71
20 mg Te/l... ..	6.62	1.02
H ₂ S passed into the bath	5.98	.71
2 mg P/ml	8.02	.57
1 mg Sb/l... ..	4.90	.34
1 mg Bi/l	1.14	.40

* after F. Koerber and H. Ploum

hydrogen penetration is achieved with cathodic hydrogen loading of the iron. Table IV shows the influence of hydride-forming elements on penetrated hydrogen quantities obtained with cathodic loading. The hydride-forming elements are mainly, Sn, Pb, P, As, Sb, Bi, S, Se, and Te. There may be some connexion between the effect that, for instance, sulphur has on hydrogen penetration and the fact that this element is very much feared during enamelling.



In order to test sheets for enamelling a simple apparatus for determination of hydrogen penetration has been developed at the Max Planck Institute⁽³⁾. In this apparatus the hydrogen is evolved electrolytically as is shown in Fig. 12. With this apparatus the influence of different heat treatments on the hydrogen penetration has been investigated. In Fig. 13 the results from such an experiment are demonstrated. From the results, which are in good agreement with previous experimental evidence regarding hydrogen penetration, it may further be mentioned that no considerable difference in penetration between thick and thin sheets was noted.

Experiments

The apparatus used for the experiments was similar to the last-mentioned. The only essential

difference was that a tube for cooling the electrolyte with air was inserted. In order to get a high overvoltage of hydrogen and a good hydrogen penetration an electrolyte of the following composition was chosen:— H₂SO₄, 70 gm per l. Hg₂Cl₂, 0.25 gm per l. As₂O₃, 0.50 gm per l.

When measuring the hydrogen penetration of a sheet as a function of time with this apparatus at constant current density and temperature a curve of the type demonstrated in Fig. 14 was obtained. In such a curve the hydrogen permeability was measured from the straight part of the curve.

Before starting with the actual experiment there were two questions to be answered:—

1. The influence of current density on the amount of extracted hydrogen.

Fig. 12 (left)—Apparatus for determining the hydrogen permeability developed at the Max Planck Institute.

Fig. 13 (below)—Hydrogen penetration curves for different treated steels at 30° C.

Area: 40 sq. cm. Sheet thickness: 1.5 mm.

Current: 2 amp. (After E. Wegner and A. Dietzel)

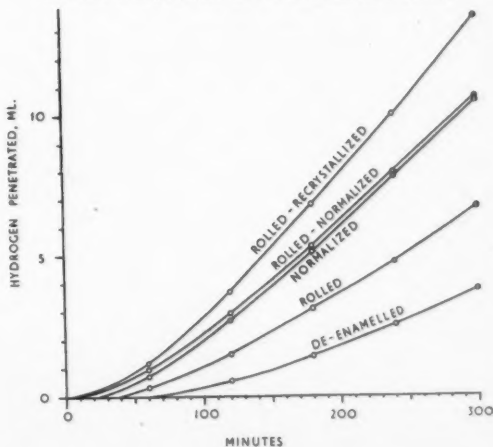


Fig. 14 (below)—Hydrogen penetration curve at 40°C. and .133 amp. per sq. cm.

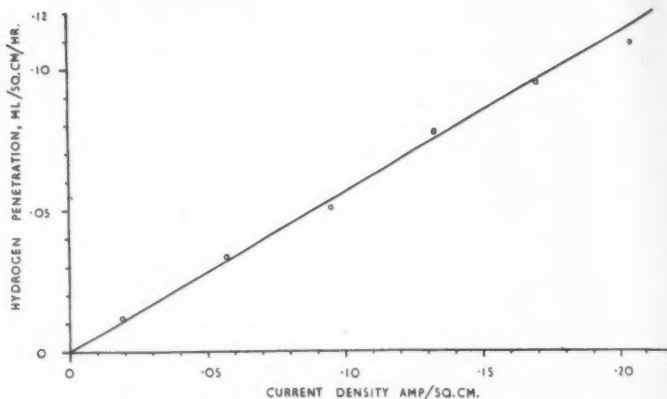
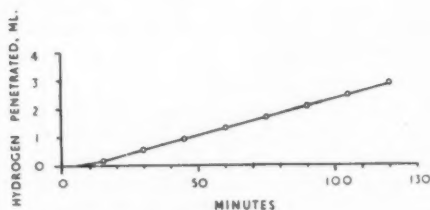


Fig. 15 (right)—Hydrogen penetration as a function of current density at 40°C.



2. The influence of temperature on the hydrogen permeability.

In order to investigate the influence of current density, the hydrogen penetration was measured on the same piece over a fairly wide range of densities at a temperature of 40° C. The results are shown in Fig. 15. Obviously the hydrogen penetration under the given circumstances is proportional to the current density or to the total amount of hydrogen evolved. Repeated experiments corroborated the results. It therefore seemed adequate to express the hydrogen permeability in ml. per amp. per hr. per sq. cm. From Fig. 15 the hydrogen permeability was evaluated to .021 ml. per amp. per hr. per sq. cm. at 40° C. The experiment was repeated at 80° C., where the same piece had a hydrogen permeability of .047 ml. per amp. per hr. per sq. cm. This shows that both the current density and the temperature must be very carefully controlled during the experiments and therefore the cooling system was inserted.

The fact that hydrogen penetration is proportional to current density was not expected. It was thought that once gaseous hydrogen was formed in equilibrium with air pressure, a further increase of current density would not influence the hydrogen activity and hence the hydrogen penetration very much. Therefore some explanation must be sought for this discrepancy. It is possible that there is not only a stream of electrons leaving the cathode jumping on hydronium ions, but also in

the opposite direction a stream of protons jumping from hydronium ions to the cathode. The same potential differences that cause certain amounts of electrons to leave the cathode, bring during the same time proportional amounts of protons to the cathode. The proportions of transported electrons to transported protons is considered to be governed by surface conditions between electrolyte and cathode and by the difference in mobility between electrons and protons. So the amount of transported protons will be controlled by the potential differences and become proportional to the strength of current. It can also be assumed that the amount of transported protons will become very small in comparison with the amount of transported electrons, considering the difference in mass and hence mobility. The mechanism for hydrogen penetration related above must with certain reservations also be valid in case of attack of an acid on metal. The results presented in Table III from experiments by Bardenheuer and Thanheiser are in agreement with this assumption.

Considering the importance of uniform surface conditions the sheets were cleaned and pickled 2 minutes in hydrochloric acid before they were inserted in the testing apparatus. Some of the pieces were degassed 2 hours at 150° C. before testing. However there was no significant difference in hydrogen permeability between degassed and non-degassed pieces. The temperature was held at 40° C. and the current density at .133 amp. per sq. cm. for all tested pieces. The tested area was 26.4 sq. cm. All pieces were 2 mm. thick (14 s.w.g.).

Concerning the influence of analysis and microstructure on hydrogen permeability the results in Table V corroborate earlier experiences. The more pure iron has lower hydrogen permeability and there is a tendency for the hydrogen permeability to increase with grain size. Any relation between the amount and distribution of slag

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TABLE V.

Analysis, grain size, hydrogen permeability, and adherence index of tested samples.

Material	Number of pieces	Analysis in 1/1000 per cent							Grain size ASTM	Hydrogen permeability mean ml/amp.h.cm ²	Adherence index mean	Remarks
		C	Si	Mn	P	S	N	Cu				
Oxygen-blown basic Bessemer rimming steel												
Charge A	7	70	nil	350	35	26	9	nil	6-7	-019	40-0	normalized
" B	3	60	nil	400	34	29	7	nil	5	-023	35-5	"
" C	6	70	nil	420	29	26	9	nil	5	-024	34-4	"
" D	6	80	nil	360	39	24	10	nil	6	-034	33-6	"
" E	6	70	nil	380	34	25	8	nil	6	-022	37-2	"
" F	6	60	nil	340	36	25	8	nil	6	-026	40-1	"
" G	6	80	nil	400	38	27	8	nil	6	-019	29-5	"
" H	6	90	nil	400	21	29	7	nil	6	-018	28-1	"
" I	6	80	nil	340	24	23	7	nil	6	-025	34-1	"
" J	6	70	nil	340	30	23	10	nil	6	-022	34-6	"
Semi-killed electro-steel	4 12	80	30	520	18	16	6	nil	3 6	-023 -018	19-3 18-1	recryst. annealed normalized
Rimming steel (Armco)												
Sheet A	4	10	nil	20	8	17	6	80	3-4	-014	33-5	recryst. annealed
" B	4	20	nil	20	8	28	8	60	3-4	-013	19-5	"
" C	4	10	nil	20	8	16	6	traces	3	-014	46-7	"
" D	4	10	nil	20	8	22	6	40	3-4	-013	27-7	"
" E	4	10	nil	20	8	28	7	50	6	-011	23-9	normalized

inclusions and hydrogen permeability has however not been established. This is not particularly surprising. Slag inclusions on the surface of iron have been shown to increase the hydrogen intake. On the other hand it can be assumed that slag inclusions inside the iron offer a certain resistance to hydrogen diffusion. As these two diverging influences cannot be separated and generally are active simultaneously, it may be difficult to estimate the slag content by hydrogen penetration measurements. Another factor to be taken into consideration is the roughness of the surface, which generally increases when the amount of slag inclusions increases, and so also makes the connexion between slag content and hydrogen permeability more dubious.

The general impression of the reliability of hydrogen penetration experiments as conducted here, is that it is not enough just to test a single piece in order to judge a steel quality, but that fairly reliable results can be obtained from a number of tests. The fairly big variations in hydrogen permeability for different test pieces even if they were taken from the same plate are probably due to variations in surface conditions. To get less scattering it would obviously be necessary to treat the test pieces in order to get equal surface conditions before testing. The time available has however not permitted such experiments to be included in the present investigation.

The oxygen-refined basic Bessemer rimming steel and the semi-killed electro steel were hot rolled which at least partly explains the greater variations in surface condition and hence hydrogen permeability compared with the cold rolled Armco steel.

Enamelling and Evaluating the Enamellability

The pieces tested for hydrogen permeability

were degreased in trichlorethylene, pickled in inhibited 10 per cent hydrochloric acid, rinsed and neutralized in a boiling soda ash-borax solution. The ground coat was applied by dipping and draining.

Firing was done in a small electric muffle furnace with the wiring wound on the outside round the muffle, to eliminate the direct radiation from the wiring on the pieces. To get a more uniform temperature along the muffle the wiring was closer at the ends than in the middle.

The temperature controller was a potentiometric instrument and the thermocouple junction was naked. The controller regulated by switching between two different voltages. These voltages could be selected by hand just to fit the temperature wanted. The samples were charged into the furnace at the moment when switching occurred from the higher voltage to the lower. In that way the heat accumulated compensated for the cooling down when charging, and it was possible to keep the temperature within $\pm 2^\circ \text{C}$. during the firing. All samples were fired at the same position in the furnace.

After firing the test pieces were kept 24 hours at 125°C . to develop delayed defects. At this temperature there is no diffusion of atomic hydrogen in the enamel. Then the adherence of the enamel to the sheet iron was measured by the Porcelain Enamel Institute standard test.⁽⁴⁾ Using a hydraulic press the samples were deformed by a 1-in. steel ball to a certain depth, differing according to the gauge of the metal. Then the area of exposed metal on the deformed area was measured by an electronic device. This was proposed to be a reliable and rapid way to get a measure of the enamellability. The adherence is expressed as adherence index, e.g. the percentage of deformed area still covered with enamel.

To get more pronounced effects a ground coat was selected with not too good an adherence and further the research die was used for deformation of the specimens. The research die gives a deeper deformation than the other dies. The specimens were fired 7 minutes at 815° C., which was within the optimum firing range for the chosen ground coat.

In Fig. 16 the adherence index is plotted against the hydrogen permeability for each single piece tested. From this no relation between adherence and hydrogen permeability can be obtained. If instead the data given in Table V are used, still no relation is obtained. That no close connexion was found, does not necessarily mean that hydrogen permeability is of no importance for the enamelling properties of steel. Not only is the amount of penetrated hydrogen of importance but it also matters if the penetration is localized to certain areas or not. In the latter respect the apparatus used is not so suitable, because the exit surface is turned down and it is difficult to observe where the hydrogen comes out when the surface is covered with already liberated hydrogen. For such studies an apparatus constructed after the principles shown in Fig. 7, where the exit surface is turned up, would be more appropriate.

The difference in enamel adherence between the oxygen-refined basic Bessemer steel and the Armco steel on one hand the semi-killed electro steel on the other hand are probably due to surface qualities. It is more difficult to get a smooth surface free from inclusions on sheets manufactured from semi-killed steel than on sheets manufactured from rimming steel. The reason why these differences in surface quality are not observed on the hydrogen penetration may be as follows:—

The surface of a semi-killed steel sheet is both rougher and contains more slag inclusions than the surface of a rimming steel sheet. Because of being rougher the hydrogen intake is decreased and because of containing more slag inclusions the hydrogen intake is increased. So it is quite possible that differences in surface quality do not show up in the hydrogen permeability test.

As known from an investigation by Richmond *et al.* (5) the initial surface roughness in itself has only little or no influence on the roughness (number of anchor points) resulting from the enamelling process and hence on the adherence. Variations in hydrogen permeability caused by variations in surface roughness only, therefore have no connexion with adherence. Pieces treated in a standardized manner for equal surface condition perhaps will show a relation between hydrogen permeability and adherence. Different types of steel are not expected to give the same relation.

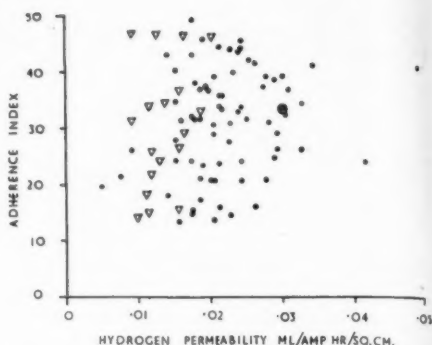


Fig. 16.—Adherence index plotted against the hydrogen permeability for each single piece tested.

Key: ○ Rimmed steel, oxygen-blown basic bessemer.
● Semi-killed electro steel.
▽ Rimmed steel (Armco).

Although the present investigation has not given any answer to the question of whether there exists a connexion between hydrogen permeability, measured at little above room temperature, and the enamellability of steel sheet, it is expected that the indications given for improvement of measuring technique may be useful for further investigation of the problem.

The work described in this paper has been carried out in collaboration between Domnarfvet Steel Works and Bath Tub Plant of AB Gustavsbergs Fabrikker in Sweden.

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DISCUSSION

Dr. B. K. NIKLEWSKI (Main Enamel Manufacturing Co. Ltd.), said that the paper touched on what was a sore point to the industry on the Continent, the question of metal. Vitreous enamellers in this country were blessed with a very good sheet iron compared with those which their friends on the Continent had to use, and for that reason there had been more research on the Continent than in this country into the sources of trouble encountered with low quality iron.

The atomic ions were so small that they could go through the lattice of the metal very easily, but the surface enamel was not, unfortunately, permeable to hydrogen, and the hydrogen by the

time it reached the enamel was no longer in the atomic form but in molecules of double the size. The enamels were not permeable to this molecular hydrogen, and so pressure was built up and there was trouble from fishscaling and so on. During the war, Continental enamellers had used boron-free ground-coats which were permeable to hydrogen, and fishscaling was unknown even with a very bad quality iron.

Many people on the Continent, particularly in Germany, had made measurements, with apparatus very similar to that described in the paper, of the permeability of iron to hydrogen with the surface covered with enamel and had measured the resistance of some enamels to fishscaling and of iron to fishscaling.

Dr. R. V. RILEY (Staveley Iron & Chemical Co. Ltd.) said that the biggest difficulty with enamel was chipping, and, so far as could be seen at present, the best way to overcome that was by the use of thinner coats. He was of opinion, therefore, that the future of vitreous enamelling was very much tied up with the possibility of getting cover-coats direct on to the steel, and thus achieving a total thickness of the order of 0.005 in. If they could do that, he thought that the future of the industry was assured.

It was in that connexion that the paper was most important. Mr. Dahlgren appeared to try to correlate hydrogen permeability purely with adherence. It would be interesting to know whether he had carried the work a little further and tried to correlate hydrogen permeability with enamelling results and cover-coats.

It was suggested in the paper that hydrogen diffused more easily in ferrite than in cementite, but it was also suggested that the diffusibility in very low carbon steels and titanium steels, which were mainly ferrite, was less than that in high carbon steels. Could that be explained?

Mr. DAHLGREN said that the relation of hydrogen permeability to enamelling results and cover-coats was something which he and his colleagues were intending to take up, but so far it had not been done. It would follow on the work described in the paper.

Mr. J. SEMPLE (Metal Porcelains Ltd.) commented on the statement in the paper that when using sulphuric acid there was a greatly increased rate of diffusion of hydrogen, the implication being that this might give rise to fishscaling and other defects, and pointed out that elsewhere in the paper reference was made to the influence of roughness, and it was said that as the roughness increased the diffusion rate decreased. This latter statement did not seem to bear out the former one, because undoubtedly sulphuric acid produced a rougher surface than was produced by

hydrochloric acid. Had the author done anything to investigate the possibility of hydrogen being removed from the steel in the later stages of the pickling process?

He could quote a remarkable experience with arsenic oxide. As small an amount as 0.001 per cent. of arsenic in sulphuric acid completely inhibited the pickling process. That was a practical application of the author's remarks on arsenic.

MR. DAHLGREN pointed out that the effect on the diffusion of hydrogen of sulphuric acid and hydrochloric acid had been taken from the published work of others. He agreed that there seemed to be an anomaly there, but at the moment he was not prepared to comment on it.

Mr. A. H. SYMONDS (Ferro Enamels Ltd.) expressed interest in the fact that with the semi-killed steel Mr. Dahlgren obtained appreciably lower adherence. With aluminium-killed steel, he said, trouble had been experienced with fishscaling. They had found that areas where the killed steel had been very heavily worked did not fishscale so much as areas which had been less worked. The very interesting study which Mr. Dahlgren had made of the diffusion and absorption of hydrogen, particularly in relation to the surface of the steel, would obviously provide some information about the fact that heavily worked and less heavily worked areas gave different results so far as fishscaling was concerned. Mr. Dahlgren's comments on that would be welcome.

Mr. DAHLGREN replied that their investigation had not yet begun to deal with fishscaling, but they were continuing their experiments and might later have some information to give.

Mr. N. F. PARKER (Stewart & Gray Ltd.), referring to what was said in the paper about the greater permeability of hydrogen with sulphuric acid than with hydrochloric acid, said he took it that that applied to experiments carried out with the apparatus shown in the paper. In their own experience they had generally found that with difficult steels better results were found with sulphuric acid than with hydrochloric acid. That might be due to the fact that in sulphuric acid the time of immersion was very much less, and the permeation of hydrogen must be proportional, he imagined, to the time for which the metal was subject to the diffusing conditions.

It had also struck him that in the apparatus shown in the paper the hydrogen diffusing through the sheet was free, whereas with the use of cold hydrochloric acid under works conditions there was a molecular film of hydrogen which at a fairly high concentration

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Hydrogen Permeability

(Continued from page 525)

might have an influence on the rate of diffusion and would, he thought, influence the rate of diffusion of atomic hydrogen into the metal. With sulphuric acid there was not the same tendency to have this high pressure layer on the surface which assisted the driving of atomic hydrogen into the metal.

The result was that in practice hot sulphuric acid might give rather better results, from the point of view of troubles caused by hydrogen diffusion, than hydrochloric acid, whereas the experimental results showed the reverse to be the case. Did the author use hydrochloric acid or sulphuric acid for pickling in his plant? That had a practical bearing on the question.

Mr. DAHLGREN said that in their plant they used sulphuric acid, because they were faced with a transport problem; they used large amounts of acid, and their plant was not on a railway line. All the acid had to be brought by road, and glass containers were heavy. In their experiments the iron had a more or less pure surface, but when pickling there might be some oxides or scale, on the surface, and that probably made a difference.

Mr. C. P. STOKES (Ferramic Industries Ltd.) said that with the basic Bessemer process in particular the gases always included nitrogen. On some occasions parallel lines appeared on the enamelled sheet. Would that be due to nitrogen, hydrogen, or rolled-in slag inclusions? He thought that it was due to nitrogen.

Mr. DAHLGREN replied that it was difficult to say. It might be a mixture. The basic Bessemer steel used in their investigation had a lower nitrogen content than the usual basic Bessemer steel.

Mr. N. S. C. MILLAR (Radiation Ltd.) asked whether Mr. Dahlgren had any experience of the use of nitric acid for pickling. He also pointed out that it was stated in the paper that the rougher the surface the less the hydrogen penetrated, but in Fig. 2 there were three curves, for polished, 1 hr. pickled, and $\frac{1}{2}$ hr. pickled respectively, and, in view of that statement, he wondered whether the naming of the last two curves had been reversed.

Mr. DAHLGREN said that they had done no experiments with nitric acid in their plant; they had rubber-lined pickling tanks and it would spoil them, and it would be difficult to keep the atmosphere of the pickling room clear of nitrous fumes. The curves in Fig. 2 had been taken from other work. Whether the authors of that other work had made a mistake Mr. Dahlgren did not know.

Mr. J. H. GRAY (Stewart & Gray Ltd.) ex-

pressed great interest in the author's remarks in connexion with the diffusion of hydrogen when cold hydrochloric acid was used, and asked whether the author had any experience of using warm hydrochloric acid, say at about 70°C. He believed that that was being used in Sweden, and he wondered whether that was because it had been found that when using hydrochloric acid there was less trouble, and by warming it up slightly it was possible at the same time to get increased production.

Mr. DAHLGREN said he had never heard of the use of warm hydrochloric acid, and they had never used hydrochloric acid in their plant. Other works in Sweden, so far as he knew, used only cold hydrochloric acid, at about 12-25°C. He thought it would be impossible to use it at 70°C., because it would disappear. It would not be practicable to use it at a higher temperature than about 30°C.

Productivity in Plating

(Continued from page 516)

articles. Outplaters, of course, were not willing to suggest such a procedure to manufacturers for whom they were working since it would involve loss of prestige.

Mr. Fyfe then surveyed the post-war developments which had taken place in electroplating techniques and processes, especially in the fields of bright metal deposition and alloy plating. He described briefly a number of bright plating processes and pointed out the practical and economical advantages to be obtained from operating such solutions, and also a number of disadvantages. Thus, for example, although bright nickel may reduce the polishing and handling costs, it suffered from certain defects in service performance in some circumstances which detracted from the advantages and might even, sometimes outweigh them. The field of alloy deposition had also been explored extensively since the war and such deposits were being used in a number of special applications, e.g., bearing metals. There had been great hopes at one time that suitable alloy deposits might replace nickel in the conventional nickel/chromium decorative and protective finish, but although extensive trials had been carried out it was eventually concluded that at the present stage of development no completely satisfactory substitute could be found for nickel.

While developments had been taking place in the type of solutions used for electroplating, improvements had also been made in the design of plating and polishing plant and Mr. Fyfe showed a number of slides illustrating these recent developments.

FINISHING POST

A SELECTION OF
READERS' VIEWS COM-
MENTS AND QUERIES ON
METAL FINISHING
SUBJECTS

Advice on all aspects of metal finishing practice is offered on these pages, and while every care is taken to ensure the accuracy of information supplied no responsibility can be accepted for any loss which may arise in respect of any errors or omissions.

I.M.F. Presidential Address

Dear Sir,

In the brief report of my Presidential Address published in the November issue of "Metal Finishing Journal" you attribute to me two statements, neither of which I think is supported by the text. Your report states: (a) that I deprecate the increasing tendency to use American processes; and (b) that many (by inference American) processes have been launched on the market in recent years in an incompletely developed state.

In introducing my thesis that, in the British metal finishing industry, the development stage is probably the weakest link in the chain my actual words were:—

"It appears probable that development is also the weakest link in the British metal finishing industry. There seems to be an increasing tendency to use American processes and it is certainly true that in the last few years a number of processes have been launched on the market in an incompletely developed state. This is bad for the industry and, in the long run, can only be harmful to the sponsors".

My reference to the use of American processes in the U.K. was intended solely as evidence of our relative weakness on the development side and no criticism of American processes was intended or implied. I shall be grateful Sir, if you will publish this letter in your next issue.

Yours faithfully,

R. A. F. HAMMOND,

President.

Institute of Metal Finishing,
32, Great Ormond Street,
London, W.C.1.

We regret that in the considerably abbreviated report of Mr. Hammond's stimulating Address his views should have been misrepresented in the manner referred to in his letter above, and we are happy to provide him with this opportunity to establish his exact meaning.

The Value of Copper under Nickel

1025. We would welcome your guidance in connexion with the plating in nickel and chromium of a number of steel articles which will be

called upon to withstand fairly severe outdoor service conditions. We have until recently used very successfully a deposit of 0.0012 in. of nickel directly on the steel followed by chromium plating and we have limited the number of articles produced so that the available nickel has sufficed to produce this thickness of coating. It is now however, essential to increase our production greatly and it does not appear likely that we shall be able to obtain sufficient nickel to continue our former practice. We are, therefore, considering the use of a preliminary deposit of 0.0003 in. of copper followed by 0.0009 in. of nickel in the hope that this will give equivalent protection. Would you confirm this view and also state whether the copper should be preferably polished prior to nickel plating?

The substance of this enquiry has been the subject of considerable discussion in recent years, aggravated particularly by variations in the acuteness of the nickel shortage. A great deal of information on the subject has been published and not all of it leads to similar conclusions. There appears to be a general agreement that the presence of copper under the nickel for a given nickel thickness does delay the initial breakdown of the coating, but when breakdown does occur it appears to proceed faster than is the case when nickel is applied direct to the steel. The view is maintained by some that polishing of the copper prior to nickel plating gives added resistance but doubts have been expressed concerning this, particularly where the subsequent nickel coating is deposited from a solution containing organic brighteners. Furthermore, if the copper is to be polished it must be deposited in sufficient thickness to allow for the subsequent polishing operation, otherwise results will undoubtedly be unsatisfactory.

A thick coating of copper (0.001 in. or more) deposited from an acid copper-sulphate bath and then polished, does give added protection and, if such a coating is applied the nickel thickness may safely be reduced to 0.0006 in.

There is also available a number of light-coloured tin bronzes deposited from proprietary solutions for which considerable success has been claimed and these would appear to have found favour in the U.S.A.

A Brief Note on the ELECTROLESS DEPOSITION OF NICKEL ON ALUMINIUM in an American Works

By T. A. DICKINSON

AN electroless plating process, now in use at Northrop Aircraft, Inc., is giving economies in operation and improving the properties of many aluminium parts for Scorpion F-89D aircraft and Snark SM-62 strategic missiles in production work at Hawthorne, Calif., U.S.A.

Coatings applied by means of the process are in many instances replacing anodic finishes; for, in addition to being applicable in less than half the time that is required to anodize aluminium parts, they have the advantage of being electrical conductors—all of which makes it relatively easy to assemble the aircraft components with adhesives, or by soldering or brazing.

While it was discovered by the National Bureau of Standards almost ten years ago, electroless plating is not a widely used process in coating aluminium due to a number of production difficulties which have now apparently been eliminated by Northrop. However, it is being extensively used in the deposition of nickel coatings on ferrous and cuprous products.

Fig. 1.—Components being cleaned in detergent solution prior to electroless plating.



It consists briefly of cleaning parts, much the same as if they were to be electroplated, and then immersing them in a plating solution which deposits a metal coating without the aid of an electric current. No current is required because the parts themselves ordinarily cause chemical reduction to take place by catalyzing the plating solution.

The process is superior to electroplating methods for a number of reasons—not the least of which is the fact that it can be used to plate the surfaces of holes and other areas which are normally inaccessible in an ordinary electroplating solution due to the relatively poor throwing power of the solution.

In the electroless plating of aluminium, large stainless-steel wire baskets and specially designed racks are used to provide proper drainage and to hold the various parts so that the optimum surface areas will be exposed to processing solutions.

Parts retained by the baskets and racks are initially cleaned in an air-agitated detergent solution.

(Continued in page 537)

Fig. 2.—General view of electroless plating plant.



Lack of success in passing examinations arises almost as frequently from failure to apply knowledge properly as from failure to acquire knowledge. This series of articles is intended to assist actual and intending entrants for the City and Guilds Certificate Examinations in Metal Finishing to answer examination questions in the most effective manner.

A Students Guide to Examination Courses in Metal Finishing

II. INTERMEDIATE (Cont.)

Compiled by **A. ALEXANDER**

(Series continued from page 500, November, 1955)

METHODS OF PREPARATION FOR ELECTRO-PLATING

Polishing

POLISHING itself is quite an important subject and a considerable amount of information on the process is available, including at least one text book.* In this syllabus a candidate is expected to know the general methods employed, but it is not expected that at the Intermediate stage he will have any great knowledge of the theoretical principles involved, and it is not proposed to deal with these here.

Metal articles are normally polished by means of rotating wheels of felt or calico, the outer edge of which is coated with a suitable abrasive. These wheels can be divided into two main classes, solid wheels made of felt or leather, or, in some cases, wood, or metal, coated with felt or leather and called "bobs", and wheels made up of loose discs of materials or in some cases, pieces of material stitched together and called "mops". The bobs are normally used for the cutting-down operations and are prepared by treating the surface with glue and then rolling in a tray of emery. The mops are normally used with an abrasive composition consisting of a suitable abrasive powder, such as Tripoli or rouge mixed with a grease binder.

The majority of candidates will probably at least have seen polishing shops in operation, and in many cases may have done a certain amount of polishing, and it is not, therefore, proposed to deal with this matter at any great length. There are, however, one or two points concerning the process which should be emphasized in as much as they may effect the subsequent operations.

Two quite definitely different actions are involved in the polishing process. The preliminary cutting down with emery or Aloxite powder is done either by a wheel to which the abrasive is glued, or by means of an abrasive belt running

over a wheel. Under these circumstances the abrasive actually scours and cuts out small grooves in the metal; metal is torn away during this process and sometimes leaves small slivers of metal on the surface. The final processes, however, involve a different type of action; the metal instead of being cut from the surface is pushed down and smoothed over rather in the same way as a surface may be polished by burnishing it with a hard stone or piece of steel. There is, of course, no hard and fast line between these processes and in many polishing operations both are proceeding together.

The effect, however, of the first process is often that small pieces of metal are left adhering to the surface of the article, and also the edges of the grooves are often jagged. If such a surface is plated directly with only a simple cleaning process, trouble often arises from this cause and the plating is found to be unsatisfactory, since the various small particles of metal and jagged edges of grooves tend to build up and produce irregular deposits.

On the other hand the surface produced by the final mopping operations has been to some extent "flowed", that is the metal has been squeezed out over it and this surface is in a highly distorted state; in addition the surface layers of the metal often do not adhere very strongly to the underlying layers so that if a deposit is made on this surface and then torn away it will often be found that it does not adhere. If the back of the deposit is carefully examined, however, a thin layer of the basis metal is found on it showing that it is not the adhesion of the deposited metal to the surface layer of the article which is at fault, but rather the adhesion of this highly worked surface layer to the remainder of the metal.

It will be apparent from this rather sketchy description that in order to obtain a satisfactory deposit, with a bobbed surface which has been finished with a moderately coarse grade of emery, it is desirable to give it some further treat-

* "Industrial Polishing" by G. Weill. (Hiffe and Sons Ltd.)

ment to remove small pieces of metal and smooth away any rough particles; similarly, with a surface which has been heavily mopped, it is also desirable to remove the thin non-adherent surface layer before applying a deposit.

Cleaning

Most final polishing operations involve the use of some type of lubricant generally a stearin or wax composition, and therefore articles coming from the polishing shop will be greasy and require cleaning. Since lubricants are also used in many machining operations, this usually applies to parts which have been pressed, turned, or otherwise fabricated. Even a perfectly clean article which has been handled with require cleaning because a certain amount of grease will be transmitted to the surface from the hands of people who have touched it.

One of the first processes, therefore, required at the plating shop is a thorough cleaning of the surface to be treated. This is perhaps the most important operation in the whole plating cycle. If a satisfactory deposit is to be obtained on a metal surface it is essential that this surface is cleaned, not only in the ordinary accepted sense of the word, that is that it shall not look dirty, but that it shall actually be completely free from any foreign material. A metal surface may appear clean on inspection, but may have a thin coating of grease over the surface, which, although too thin to be seen will completely upset any further operations that are conducted on it. This last trace of grease is often extremely difficult to remove.

In the parlance of the plating shop cleaning usually refers to the removal of grease, oil, polishing composition, and extraneous matter, but does not normally refer to the removal of thin films of oxide or other metal salts that may be present. In the subsequent matter this term will be used in the above sense.

Several methods of cleaning are used and it is necessary that the candidate for the Intermediate examination shall be familiar with these methods and be able to describe the processes; he will not, however, be expected to enter into any theoretical discussion on their action.

The methods in use may be roughly divided as follows:—

(a) Cleaning By Means of a Solvent.

Certain materials usually organic liquids such as trichlorethylene, petrol, paraffin, benzene, etc., will dissolve grease. Grease, therefore, may be removed by dipping the article into one of these solutions which will dissolve the grease away from the surface. It is, however, evident that after the solvent has been used once or twice, a

certain amount of grease will be dissolved in it and when the article has been withdrawn, the thin layer of solvent remaining on the surface will, in point of fact, be a solution of grease in the solvent. When this evaporates a film of grease will remain, although it will be much thinner than the original.

To overcome this difficulty an apparatus known as a "de-greaser" is used in which the solvent is boiled in the bottom, the vapour rising to the top and being cooled by means of a cooling coil. When the cold article is placed into the vapour this condenses upon it, producing a film of quite clean solvent, which removes the grease and carries it to the bottom of the apparatus. In operating this equipment, however, it must be remembered that the article must be cold, or reasonably so. Some of these degreasers have also a compartment for boiling liquid and for some purposes it is convenient to immerse the article in this boiling liquid before treating it in the vapour compartment. Often an operator will immerse the article in the boiling liquid for some few seconds and then transfer it without allowing it to cool, into the vapour compartment. If this is done the vapour will not condense on the article and the apparatus will not function correctly.

It is apparent that an apparatus of this type must employ a non-inflammable solvent. Trichlorethylene is normally used as the most convenient, although both perchlorethylene and carbon tetrachloride can be used. While theoretically an apparatus of this type, if correctly employed, should produce a surface completely free from grease, it is found in practice that articles cleaned in this apparatus alone cannot be satisfactorily plated directly. It is probable that there still remains a very thin film of grease or other material, and in any case the article when it is withdrawn from the surface is dry and not wet and if dipped into a tank of water and withdrawn it will be found that the water film "breaks" and does not remain as a thin film over the surface. The articles cleaned in this apparatus are however in a very suitable state for painting.

(b) Emulsion Cleaning.

The degreaser described above is a very convenient method of removing polishing composition, oil, etc. Another method, however, which is being used is the process called emulsion cleaning. This consists in using a solvent combined with an emulsifying agent which will dissolve the grease. In some cases this solvent is suspended in water so that it takes off grease directly in one process, while in other cases the article is first dipped in the solvent and then

immersed in a tank of water in which the emulsion is formed. Due to the presence of the emulsifying agent, the grease solvent with the grease dissolved in it forms an emulsion with the water, that is to say the solvent becomes suspended in very fine droplets producing a kind of "milk." Most of these cleaners are proprietary, that is to say their exact composition is not disclosed. It is sufficient for an Intermediate candidate to be aware of the general idea of the process.

(c) Alkaline Cleaning.

Grease may be removed from a metal surface by treating it with a solution of certain alkalis, preferably used hot. Many greases are directly attacked by such materials as caustic soda producing a soap and could therefore be removed in this way. This process is called saponification, meaning literally "the formation of soap". Some greases, however, are not attacked by caustic soda but can be removed by certain alkalis, such as sodium carbonate, tribasic sodium phosphate, or sodium metasilicate. These materials produce an emulsion with the grease and suspend it in the solution. Most of the modern cleaning solutions are combinations of such materials, the phosphates and silicates being used for light cleaning, that is to say, the removal of the last traces of grease and caustic and carbonates being used for heavy cleaning. These latter are somewhat apt to stain the surface, particularly brass or copper. The composition of the cleaner will, therefore, be governed by the amount of grease that is to be removed and the type of surface on which it is required to work. If a heavy soil has to be removed from steel machine parts it is possible to use a fairly high concentration of caustic soda, but if such a cleaner were used for cleaning polished brass work, it would stain the surface badly and this stain would have to be removed before plating. Cleaning solutions of this type are normally worked hot, just to boiling point. Since the solutions do not attack steel they can be used in an unlined steel tank which may be heated with steam pipes or directly with gas jets. The solutions become exhausted on working, but may be maintained for a time by adding further quantities of the cleaning materials. It is generally preferable, however, not to work such solutions too long as they tend to become loaded with grease, but usually when the solution is cool the grease will float up to the top and form a scum, or in some cases a solid layer, which can be skimmed off. In most commercial plating shops the cleaners are changed at definite intervals, sometimes weekly, sometimes oftener. It is not advisable to wait until trouble occurs in the plat-

ing bath before a cleaner is changed, but it is impossible to lay down any time interval because this will obviously depend on the amount of work going through the bath and the amount of grease there is in it. Thus an alkaline cleaner which is working immediately following a well run degreasing plant is better than one which is cleaning work which can not be put through an organic solvent or preliminary cleaning process.

(d) Electrolytic Cleaning.

Sometimes current is used to assist the cleaning process. Alkaline solutions of the same general type as that described above are used but the work is made either the anode or the cathode in this solution, and a fairly high current generally of the order of 100 amp. per square foot, is passed between the work and the tank, or if preferred, some electrodes hung in the tank.

If the work is made the cathode, hydrogen, is evolved on its surface and this hydrogen tends to assist in the removal of the grease, both by attacking it and by the mechanical action of the bubbles passing up the surface of the work. If it is made the anode, oxygen, is liberated instead of hydrogen. It is apparent, of course, that this action will be somewhat less violent, since only half the volume of oxygen will be liberated for the same amount of current. In this case also, it is necessary to make sure that the article being cleaned will not be attacked by the solution. Steel articles can be cleaned quite satisfactorily as anodes in alkaline solutions, provided no chloride is present. Some non-ferrous articles, however, are attacked under these conditions and there are also some solutions which cannot be used in this way.

There is at present, some difference of opinion as to whether the article should be made anode or cathode, various claims being made for each process. The Intermediate candidate is not required to go deeply into this matter, but should be aware that both processes can be used on occasions.

Electrolytic cleaning baths are generally used for final cleaning operations; for the most part they are used hot but may be used at room temperature for some purposes. In general, if it is required to use these cleaners at room temperature a small addition of cyanide is added to the solution.

Rinsing.

Rinsing is extremely important in the plating cycle and many plating troubles can be directly ascribed to careless or insufficient rinsing. Normally an article will be rinsed between each process, although if the article is being taken out of a hot alkaline cleaner to go into a warm electro-

lytic alkaline cleaner it is sometimes preferable not to rinse the article between these two baths.

The purpose of rinsing is to remove all the solution in which the article has been immersed, together with any other loose material which may be on its surface. In the ideal case when the article is withdrawn from the rinse it will have nothing but a film of water over the surface. If the article is clean this should be a continuous film and if the article is held in the air for some seconds the film should not break. If the film breaks and the water trickles into little globules this is normally spoken of as "water break" and shows that the surface of the article is not satisfactorily cleaned. After the cleaning cycle water break should not be obtained at any point in the process.

In order to obtain the object of rinsing set out above, the rinse tank must be full of clean water. This, however, is often overlooked and in many plants a common rinse is used for several processes and the rate of change of this rinse is so low that it becomes contaminated with different chemicals. In many cases, also, although water is run through the rinse it is run in at the top and overflows at the top so that in point of fact the clean water does not reach the major part of the rinse which remains contaminated by the solution rinsed off the articles treated in it. Very soon the tank becomes useless.

It would seem a very evident fact, but it is often neglected, that the tank must be kept supplied with an adequate quantity of clean water, reasonably free from any material which is likely to cause trouble. It will also be appreciated that circulation of this water in the tank must be such that it keeps the whole tank clean and not just the top layer.

In rinse tanks used in plating shops it is usually arranged for the water to run through a pipe to the bottom of the tank and to overflow from the top of it. It is desirable at some point that the flow of water should be able to be observed; in some cases air agitation is also arranged on the tank to keep the water stirred and to assist in the removal of the solution from the article. For many purposes, particularly immediately before entering the plating tank, it is desirable to have a double rinse. This is a tank arranged with two compartments, the water entering first one and then overflowing into the other. The article is first rinsed into the compartment next to the overflow and then into the compartment next to the inlet. In this way the final rinse is kept reasonably free from contamination.

It must be remembered that the water from the average supply is by no means pure and may contain quite a high proportion of calcium salts. A hard water of this type, if used in a rinse

immediately succeeding a hot alkaline cleaner, may form a scum of lime soap over the surface of the article which is very difficult to remove by subsequent processes. Where the water supply is known to be hard it is desirable to soften it, although to some extent the action can be mitigated by having this particular rinse warm.

The question of rinsing here has been stressed because of its importance in the plating cycle, a candidate for the examination will not be expected to deal with this subject at any great length, but in any plating process which he describes he should definitely stress the importance of satisfactory rinsing in the operation, state at what points rinsing is to be undertaken and in phrasing his answer show that he is aware of the importance of the operation and the precautions to be taken.

In the majority of cases work is rinsed, as mentioned above, by dipping it into a tank of water, but in some cases sprays are employed which direct streams of water at the article in question, removing the solution from the surface in this way. This type of rinsing, if properly designed can be more efficient but it is somewhat expensive in water unless the water is recirculated which may be undesirable due to contamination.

Removal of Oxide Films, etc.

As mentioned above, the article after cleaning, should be completely free of grease and other foreign matter, but may still have on the surface a film of oxide, sulphide, etc. In some cases this film may be merely a tarnish film which is relatively thin or may be quite invisible, such as the film that forms on a surface of aluminium. In other cases it may be a heavy scale. Work which has been machined or polished will not have a scale on the surface and the thin tarnish film which normally forms can easily be removed by passing it through a light acid or cyanide dip. Where, however, it is necessary to remove a scale this may require some type of "pickling" process.

Pickling.

A pickle generally refers to an acid solution used for removing scales, oxide films and the like. For steel and also brass and copper, the more usual solution is a solution of sulphuric acid, generally about 10 per cent, worked warm. Sometimes, however, steel may be given a slow pickle in a 2 or 3 per cent sulphuric-acid solution containing a substance known as a "restrainer", that is something which prevents the acid from attacking the steel but does not prevent it from attacking the oxide film. Many such restrainers are proprietary chemicals, but glue

can be used for this purpose. The quantity required is generally quite small, usually below 1 per cent. A number of pickling acids are used for various alloy steels and different types of non-ferrous alloys. Hydrochloric acid in fairly high concentration is sometimes preferred for steel, but is more expensive to use, although it can be used without heat. Mixtures of sulphuric and nitric acid of which the most popular is known as "Acky" (and consists of two parts by volume of sulphuric, one part by volume of nitric acid and one part of water), is used for dipping brass and will produce a reasonably bright surface if correctly used. Certain special pickles are also used for removing the very thin continuous oxide layer on aluminium, but the plating of aluminium does not enter into the Intermediate syllabus and will not be discussed here.

An Intermediate candidate should be aware of the purpose of the pickling operation and the type of acids used for steel, brass and copper. If he can describe the type of solution used and the reason for its use for the three materials above, this is all that is required.

For many purposes, articles may be pickled prior to polishing. If the articles are greasy when received it will obviously be necessary to clean them before the pickling process, but for some purposes they will pickle directly as for this process their complete freedom from grease is less important than for plating.

Removal of Tarnish, Film, etc.

A polished article which has been cleaned will normally require a final dip before it is in a suitable condition to enter the plating vat. This dip will remove the last traces of oxide film. Steel articles are generally dipped in 10 per cent sulphuric acid used at room temperature; in certain cases, however, they may be given what is known as a "anodic etch", that is to say, they may be made anode at a fairly high current density generally at the order of some 200 amp. per square foot in an acid solution. If they are made anode in a dilute sulphuric acid, say 30 per cent by volume, they will be slightly etched. While this process is quite satisfactory when building up thick deposits of nickel which have afterwards to be mopped by hand, it will not be satisfactory for the deposits required to be made in a modern bright nickel solution which will have to be directly chromium plated. In such a case much more concentrated solution of sulphuric acid, with a density of about 60 to 65 Bé as used, which does not etch the surface. These anodic etches give a very high adhesion, but are a little more difficult to carry out on many types of work and it is more normal after a cleaning operation to

dip merely in acid and then thoroughly swill.

Brass and copper articles may also be dipped in 10 per cent sulphuric acid but if they have a tarnished film on them when withdrawn from the cleaner this is usually first cleared in a solution of sodium cyanide containing some 4 oz. per gal. of cyanide worked at room temperature. If the article has to be plated in alkaline solution it may, after rinsing, be transferred directly to the plating vat, but if it is to be plated in an acid solution it is preferable to pass it through the acid dip first.

Typical Cleaning Cycles

Apart from a general knowledge of the cleaning procedure, an Intermediate candidate will be expected to know the typical cleaning cycles for steel and brass articles. These cycles vary somewhat in different plating shops, but any cycle which would produce a satisfactory result will be considered to be a correct answer. A typical cycle, however, for steel and brass will be set out below as an example:—

STEEL. It is assumed that the articles are of polished steel and come from the polishing shop directly:—

1. Pass through the liquid chamber of trichlorethylene degreaser.
2. Withdraw and cool.
3. Pass through vapour of degreaser.
4. Remove and immerse for 3 minutes in hot alkali soak cleaner.
5. Rinse.
6. Immerse for 2 minutes in anodic alkaline cleaner.
7. Rinse.
8. Dip in 10 per cent sulphuric acid.
9. Rinse twice in double-compartment rinse tank.
10. Plate.

BRASS. It is again assumed that the articles come straight from the polishing shop:—

1. Immerse in liquid compartment of trichlorethylene cleaner for a few seconds.
2. Remove and cool.
3. Pass through vapour compartment of degreaser.
4. Remove and immerse for 2 minutes in cathodic alkaline cleaner used warm.
5. Rinse.
6. Dip in 4 oz. per gal. sodium cyanide.
7. Rinse.
8. Dip in 10 per cent sulphuric acid.
9. Rinse in double-compartment rinse tank.
10. Plate.

In answering these questions the candidate

should stress the importance of rinsing and the fact that a separate tank should be used for each rinse.

Adhesion of Deposits.

It will be apparent that the adhesion of the deposit made, upon a metal surface, depends very largely on the correct carrying out of the cleaning and preparation processes, although even if these have been carried out correctly, it may still be possible to obtain unsatisfactory adhesion due to some fault in the plating tank, particularly incorrect current density at the start of the operation and contamination of the solution.

If a deposit does not adhere satisfactorily it may actually strip off during the plating process, since this process normally produces a fairly high stress in the deposit which will tend to make it curl away from the article being plated. However, this is by no means always the case and it is quite possible to produce a deposit which appears satisfactory on a visual inspection, but does not adhere to the basis metal and can quite easily be stripped.

In the laboratory there are certain methods by which the adhesion of a deposit can be measured quantitatively on specially prepared test-pieces. It is, however, not possible to make quantitative measurements in the plating shop and the laboratory methods are outside the scope of an Intermediate candidate. One or two somewhat empirical methods are, however, used to test whether the deposit is likely to be satisfactory or not, from the point of view of adhesion, and the candidate should be aware of these methods and be able to give a brief description of them. They are as follows:—

1. The article may be rubbed with a piece of metal, for example a copper coin held edgewise. If the adhesion is bad, the deposit may blister and if it does so it is a certain indication that the adhesion is unsatisfactory. Unfortunately, the converse is by no means true but this test is given in certain specifications because it is extremely difficult to test a deposit in any other way. A steel or agate burnisher may be substituted for the coin. Some effort has been made to improve this type of test by using a number of ball bearings dropping from a given distance on to the surface, or a vibrating hammer operated electrically. This type of apparatus, however, has not found much favour in industry.

2. The deposit may be cut through, preferably on the edge of the article by means of a file or grinding wheel, and efforts may then be made to detach it by inserting a knife blade or similar tool between the deposit and the basis metal. If the deposit can be detached easily, that is to

say, if it can spring away from the basis metal, the adhesion is said to be bad. If the adhesion is good, it should be practically impossible to detach, although if the deposit is thick and ductile it may sometimes be possible to rip it off if sufficient force is applied. It is claimed that some measure of adhesion (good, bad or indifferent) can be gained in this way, but this is very doubtful. Bad adhesion, however, is fairly obvious.

3. If the article is heated to some 200°F a deposit which does not adhere will often blister and in some cases articles are heated in this way regularly from the point of view of inspection, and if blisters appear they are rejected. For some purposes, also, the actual heating operation improves the adhesion.

4. A rough idea of adhesion can sometimes be obtained by sticking a piece of sticky tape on to the surface of the deposit and then quickly ripping it off. If the deposit is removed or blistered it is obviously unsatisfactory.

5. A small square of deposit may be isolated by cutting two sets of grooves at right-angles, efforts can then be made to detach this square by means of a knife; if it can be removed easily, the adhesion is unsatisfactory.

It will be seen that all these tests are qualitative only and none of them are particularly good. In some cases it is necessary to destroy or damage the article to make the test. A number of other tests may be made from time to time, but they are generally specific to the article in question. It will be sufficient from the point of view of the examination if the candidate can list the above tests, giving a very brief description, but he might well point out the unsatisfactory nature of these tests at the moment. He should be aware that quantitative tests could be made on specially prepared surfaces but it is not necessary for him to describe these in any detail. A quantitative test has lately been put forward by Brenner in which a small nodule of cobalt is deposited on to the surface of a nickel deposit and then pulled off with a spring balance. If this operation is correctly performed it will pull the deposit with it, and the stress required can be measured, but at the moment this test is a long way from being able to be used for commercial purposes, and except for mentioning this test it is not necessary for a candidate at this stage to discuss it.

Anode Reactions.

In a plating process the anode is, of course, of considerable importance, but strangely enough is often neglected in practice. It is often practice to hang a number of anodes of the metal to be

(Continued in page 537)

Some Investigations into the ACID PICKLING OF MILD STEEL

A Report of the Discussion of a Paper* by D. JACKSON, B.Sc., A.R.C.S., A. J. STEDMAN, M.A., A.R.I.C., and R. V. RILEY, Ph.D., B.Sc., F.I.M. presented at the International Enamelling Congress, Leamington Spa, Oct. 1955

AFTER presenting his paper, Mr. D. JACKSON (The Staveley Iron & Chemical Co. Ltd.) said that he would like to show how the results could be used in putting into perspective ideas of pickling in various shops. For that purpose he had prepared a calculation as a demonstration. He assumed that with an average cooker there was a sheet area of approximately 40 sq. ft. (The figures which he gave were not supposed to be based on real practice.) He also assumed that the drag-out from the pickle was about 1 litre on that area of sheet. He thought that that figure was approximately correct, but to check it all that had to be done was to start with a fresh swill, seal it off, put a number of baskets through it, so that washing was effected into a known volume of water, then estimate how much acid had been dragged over. He had used the rates of attack given in the paper and with hydrochloric acid the loss by attack on 80 sq. ft. of surface was 11 gm. and the loss by drag-out 120 gm., a total loss of 131 gm. The rate of attack was not very dependent on strength and it was thought that by raising or lowering the strength the attack would not vary very much. With sulphuric acid the loss from attack was 170 gm. and the loss from drag-out 70 gm., a total of 240 gm. The cost of pickling worked out at 1.27d. per cooker with hydrochloric acid, or £5 6s. per 1,000 cookers, and at 0.74d. per cooker, or £3 2s. per 1,000, with sulphuric acid. The sulphuric acid, of course, had to be heated. Enamellers might find it interesting to do some such calculations on their own plants.

The calculation he had just given could be set out in tabulated form as in Table 1.

TABLE I

Approximate area of cooker	...	...	40 sq. ft.
Approximate drag-out	...	...	1 litre
HCl			
(27.5°C. 30 min.):	Loss by attack (12 mg. Fe per 106 sq. cm.)	...	11 gm.
	Loss by drag-out	...	120 gm.
			131 gm.
H ₂ SO ₄			
(66°C. 10 min.):	Loss by attack (140mg. Fe per 106 sq. cm.)	...	170 gm.
	Loss by drag-out	...	70 gm.
			240 gm.

Cost: 1 gm. HCl, 0.0097d. 1gm. of H₂SO₄, 0.0031d.
Cost of pickling: HCl, 1.27d. per cooker or £5 6s. per 1,000. H₂SO₄, 0.74d. per cooker or £3 2s. per 1,000.

It could be concluded from these calculations that with cold hydrochloric-acid pickling on bright-steel pressings (not descaling) the iron content could rise only extremely slowly and could never exceed 9 to 10 gm. per litre, or about 1 per cent. If it was above 1 per cent for any reason, such as, for example, if scrap or a few components had been dropped in the bottom, it should fall to that figure, because the drag-out would exceed the rate of attack on the work going through. He had often heard the comment that "our hydrochloric acid is losing its iron." His reply had always been: "Increase the temperature and the iron content will rise, because the rate of attack will be increased."

The cost of the acid with hydrochloric acid lay largely in the drag-out, and by using weaker acid, slightly warm, the drag-out loss would be substantially reduced. To warm it slightly would not cost very much. With sulphuric-acid pickling what was important was the rate of attack on the steel. If that could be reduced from 170 gm. to 68 gm. per cooker, the iron content would probably rise quite slowly to 6 per cent and it would be possible to use the acid much longer and reduce the loss on the acid thrown away. There would be a saving on the loss of acid due to the attack, and the cost per 1,000 cookers with sulphuric acid would come down from £3 2s. to £1 16s.

He assumed that a reasonably vigorous etch was still required. Some authorities in the industry seemed to insist on the greatest possible etch, but others did not think it so necessary. Mr. Jackson expressed no opinion, but said that if it was possible to reduce the etch a fair amount of acid could be saved by putting in a mild inhibitor. One of the surface-active agents would be helpful, because it would help to remove the smut during pickling as well.

The last calculation which he had made from the figures he had given was that it would take 1,900 cookers to bring 1,000 gallons of solution up to a 6 per cent iron content at the assumed rate of attack. That would require another £3 14s. to re-make the bath, and if that could be avoided or substantially reduced there would be

*Published in METAL FINISHING JOURNAL, October 1955 issue.

a further saving.

The CHAIRMAN (Mr. W. Thomas) said that in recent years a number of papers had been written on pickling, but Mr. Jackson and his colleagues had approached the subject from a different angle and had come to conclusions which were contrary in some cases to views held before. They had brought to light some new points, and there was likely to be some controversy on the subject in the technical press at a later date, when the comments made in the paper were seen.

Mr. I. E. MURDOCH (R. & A. Main Ltd.) said that the authors had given an enormous number of figures, and it was very difficult to assess, without a longer time for their consideration, the full value of the facts put forward. Referring to the relative costs of the two types of pickling, he said that Mr. Jackson had given some very significant figures. In Mr. Murdoch's works hydrochloric acid was used, because with sulphuric acid the problem of ventilation was more difficult; the hydrochloric acid, however, was heated by the introduction of hot wave from the hot rinse after the alkali degrease and also by the speed of reaction in the solution. When a fresh tank was made up warm water was used.

If the acid, however, was to be heated what method could be recommended? In the past an attempt had been made to heat it using Monel metal coils, but these had been attacked by the hydrochloric acid so rapidly that every two or three weeks the acid strength was found to be markedly reduced due to the introduction of condensed steam.

Mr. JACKSON said he was glad to know that Mr. Murdoch tried to keep the hydrochloric acid warm, because that was most desirable. With regard to the method of heating it, it was possible to use a jacketed rubber-lined tank, or an ebonite coil. With an ebonite coil the heat transfer was very poor, but was just enough to give the warmth required. A Vitreosil immersion heater or a stainless-steel coil should also be satisfactory.

Mr. J. SEMPLE (Metal Porcelains Ltd.) referring to page 1 of the paper, asked why the authors used 10 per cent by volume of sulphuric acid. That was very much stronger, he said, than anything his company had used for sulphuric-acid pickling they used 7 per cent by weight, while the authors' figure would work out at about 18 per cent by weight. He did not know whether that might explain certain results which seemed to him anomalous; probably the loss of weight was excessively high due to the very strong acid used.

What had been said about the use of sodium chlorate went, he felt, to the heart of the matter

so far as etching was concerned. Loss of weight did not give any measure of the type of surface produced, which, he felt, was of paramount importance. In future work it might be possible to correlate the results obtained either with the micrographic section or with some other means of measuring the etch on the surface. In that connexion, chromic acid would appear to be very effective. It was possible to pickle in concentrated solutions of sulphuric acid in order to get the high weight losses which the authors reported, and produce nickel deposits of the order given in the paper, without achieving very good adherence of light-coloured enamels, but the use of small quantities of dichromate in the sulphuric acid immediately produced good adherence.

Mr. JACKSON pointed out that the work in which 10 per cent by volume of sulphuric acid had been used had not necessarily been done for the enamelling industry, and in the steel pickling industry it was common to use higher strengths. The authors had kept to that strength in order to correlate results together, but they did not think that as a consequence the order of the figures or the principle brought out by the figures was going to be changed very much.

Mr. SEMPLE said that in the calculations which Mr. Jackson had given at the end of his introduction of the paper he had made use of the figures in dealing with the economics of cooker production.

Mr. JACKSON replied that in those calculations the figures for drag-out were for the strengths normally used. He agreed that the attack figures might not be quite correct, but they showed the order of what happened, and the drag-out figures were correct.

Mr. SEMPLE objected that Mr. Jackson had used concentrations of acid not normally employed in the industry.

Mr. JACKSON said that that could be checked by calculating the build-up of iron in the tanks on a practical scale.

A speaker asked whether the work described had been done, as he presumed it had, under laboratory conditions, and, if so, whether distilled water had always been used. On being informed that the answer to both questions was in the affirmative, he asked whether the authors would expect big differences in their results if various types of water, such as very hard water and so on, were used.

Mr. JACKSON said that Dr. Riley was in a better position to answer that question than he was. He noticed Dr. Riley shook his head, presumably to indicate that the hardness of the water would not affect the results, and Mr. Jackson was inclined to agree with him.

(Continued in page 538)

A Students Guide

(Continued from page 534)

plated in a plating bath and then forget about them until after some time it is found that they have all dissolved away. The correct functioning of the anode is of great importance in maintaining the bath in a satisfactory condition and an anode must not only dissolve away at the correct speed to maintain concentration of the metal salts, but must also do so without producing contamination of the solution, either by foreign materials or by small insoluble particles of the metal being plated. An anode, therefore, is not merely a lump of metal attached to a hook, as has sometimes been suggested, but is, in point of fact, a piece of metal whose chemical composition and physical structure has been carefully controlled so that it will function satisfactorily under service conditions.

At the Intermediate stage it is not expected that the candidate will discuss this matter in any great detail. He should, however, when describing any plating process, make some mention of the anodes to be used, and point out whether these are soluble or insoluble, that is whether they are designed to dissolve in the solution and maintain the metal salt content, or whether, as in the case of chromium, they will remain insoluble and the metal content has to be maintained by other means. He should also be aware that a satisfactory anode must not only be of correct purity, but must have such a crystal structure that it will dissolve efficiently without going into holes and forming excessive sludge. This is usually obtained in practice by suitable mechanical and heat treatment after casting.

For many plating processes also, it is normal procedure to cover the anode with a bag of suitable material (calico, nylon, Terylene) to prevent small particles of sludge entering the solution. Where such precautions are desirable, they should be stated in describing the process.

Some mention should also be made of the desirability of removing and cleaning anodes from time to time, of the importance of seeing that the contact between the anode and the vat bar is satisfactory, and the necessity of keeping the anode satisfactorily bagged when necessary, and in a clean, workable condition. These points should be brought out in any question involving a plating process and where possible, the nature of the anode and some mention of its purity should be made, thus if a nickel plating process is being described, it should be mentioned, for example, that the anodes should be of the normal oval "depolarized" type, enclosed in a Terylene bag. They should be provided with a suitable hook of metal and care should be taken to see

that they make a satisfactory connexion on the vat bar. They should be removed and examined from time to time and the bags carefully washed out and should be replaced when the part below the solution is worn out.

In the case of an insoluble anode used in the chromium process, the following might be taken as a typical example:—

The anode used in the chromium bath should be made of 7 per cent antimonial lead. This lead should be cast on to a copper hook which should make a good connexion with the anode bar. The anode should be removed periodically for examination, and when working satisfactorily should be coated with a chocolate-coloured film of lead peroxide. If they become coated with a yellow film of lead chromate, they should be removed from the bath and carefully cleaned off with a wire brush before re-inserting. They should not be left in the solution for long periods when the bath is not operating.

(Series to be continued)

Electroless Deposition of Nickel on Aluminium

(Continued from page 528)

tion for at least five minutes at 180° F. (83° C.). Then, after a hot-water rinse, the parts are dipped in a deoxidizer at room temperature. This is followed by a cold-water spray rinse and immersion in the plating solution for about three minutes, after which the parts are again spray rinsed with cold water and allowed to dry.

The active constituent in the plating solution is a proprietary product of Allied Research Products, Inc., Baltimore, Md.

Some difficulties have been experienced in processing parts with stains and other discolourations caused by heat treatment, but these are now being avoided whenever necessary by etching the components prior to cleaning them.

Parts whose configurations prevent proper drainage are oven-dried after the plating and final rinsing operation.

Defective areas, due to the contact of parts with basket and rack surfaces during the plating operation, are touched up by using a brush to apply the plating solution.

Where the parts were anodized, bonding brushes or fine abrasives had to be used before they could be assembled with such components as fuel valves and, exposed edges had to be coated with varnish or chromate paint in order to prevent corrosion following the assembly work. According to Northrop officials, savings due to the elimination of these operations alone will more than offset the cost of the new electroless plating facilities in a year.

Successful Application of Electrolytic Polishing in Industry (Continued from page 515)

chromium deposit, as well as the steel surface at the interface, properties differing from those obtained by mechanical surface finishing and pickling.⁽⁹⁾

Practical experience further shows that pieces chromium-plated in this manner behave far better in service. On the other hand, electrolytic polishing also simplifies the hard chroming process since the elimination of surface roughness (protuberances) in the foundation metal enables a very smooth coating to be obtained, not requiring subsequent grinding, and thus enables thinner coatings to be used.

Thus shock-absorber spindles on heavy vehicles (lorries, tanks), chromium plated on an electrolytically polished surface, have worked satisfactorily, while rods plated in the usual way have frequently failed by stripping of the plating. The results obtained appear to be sufficiently conclusive, and the extra cost of treatment is reasonable enough to enable it to be considered also for the shock absorbers of ordinary cars.

Electrolytically polishing before hard chroming has also been applied to press tools (matrices, dies

and punches), for drawing, stamping and moulding plastic materials.

Finally the possibility of electrolytic polishing of the chromium-plating itself offers advantages in obtaining a degree of surface porosity favourable for lubrication (porous chromium plating of piston rings).

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Investigations into the Acid Pickling of Mild Steel - Discussion (Continued from page 536)

Mr. Jackson also agreed with another delegate who suggested that a useful addition to the paper would be a further table giving the results on enamelled plates, particularly with regard to adherence.

Mr. H. LAITHWAITE (Metal Porcelains Ltd.) said that as compared with the steel industry the word "pickling" might mean something a little different to the enameller. Were enamellers concerned with de-scaling metal or, as Mr. Semple had suggested, with the physical condition of the metal after pickling? Mr. Laithwaite suggested that they were more concerned with the type of surface after cleaning than with scale removal, whereas the steelmaker was more concerned with the removal of scale.

If that were so, it was necessary to view with some caution some of the conclusions which might otherwise be drawn from the authors' work. He would himself be rather doubtful about drawing too strong a conclusion from a loss in weight only. He felt that, as had already been said, with the same loss in weight different sheets could be in a very different condition for

enamelling; experimental work done on the lines which Mr. Murdoch had suggested, viz., enamelling plates and examining them microscopically, showed very different forms of surface, and that was of particular significance when it was a question of treatment, with white enamels.

He did not intend that as a criticism of the paper, but rather as a suggestion for the extension of the kind of work which the authors had done. They had made a scientific approach to the subject, and they were to be congratulated in presenting the work in that way. It should be borne in mind that the strength of the acid was, as had already been pointed out, a long way removed from the sort of strength normally used in the enamelling industry. Sulphuric acid was normally used in the industry at 6 to 7 per cent by weight or 4 per cent by volume. Possibly the results in certain cases would have been a little different had the acid been weaker.

Mr. JACKSON pointed out that in the introduction to the paper it had been said that for every test carried out it was possible to think of two more. They had not had enough time to do all that they could usefully have done, but he hoped that what had been done and said would encourage others to think further about the subject and possibly to institute investigations along similar lines in their own works.

FINISHING

NEWS REVIEW

NEW PROFESSIONAL ASSOCIATION

Design Consultants form Federation

THE formation of a new technical and professional association, the Federation of Engineering Design Consultants whose headquarters, for the time being, will be St. Stephen's House, Westminster, London, S.W.1, has been announced.

As the name implies, the Federation draws its members from the ranks of firms of design consultants and contract drawing offices serving the engineering industry. The chairman, Mr. Ray Body, of E. G. Irwin & Partners Ltd., has issued the following statement: "In forming the Federation of Engineering Design Consultants we are following the logical course of development to which all new industries are, sooner or later, subjected. Our function is neither of long standing nor entirely new. It has become crystallized in its present form as the result of trends in engineering production methods. We have been an integral part of Industry for some time; and it is because we must begin to understand and cope collectively with the very great responsibilities which go with the trust increasingly placed in our professional services by Industry that this step has been taken.

Naturally, the first aim of the Federation is to represent forcibly the interests of our industry; but these interests are closely associated with the interests of our clients and the skilled employees who serve our profession. We want to establish and maintain a standard of service which is high in the aggregate—higher by far than, perhaps, the present average. We shall be quite adamant in respect of one thing: the members of this Federation shall be those firms only which are willing and able to subscribe to the best if not to say the most exacting standards of output and professional conduct."

Mr. Body's statement, occasioned by the official incorporation of the Federation, coincides with the despatch of letters to all firms at present known to be engaged in engineering design consultancy; in which these as well as other basic principles are set out in detail.

SOCIETY OF
BRITISH PAINT
MANUFACTURERS*Annual General Meeting*

THE eleventh annual general meeting of the Society of British Paint Manufacturers was held at the Dorchester Hotel, London, on Tuesday November 8th. It was announced that Mr. C. D. O'Sullivan had been appointed President, and Mr. T. S. Dally Vice-President for the year 1955/1956.

The five vacancies on the Council were filled by the election of the following:—

Mr. N. M. Hadfield
(Hadfields (Merton) Ltd.)

Col. F. W. Jones
(Leyland Paint & Varnish Co. Ltd.)

Mr. D. McR. Massie
(Donald Macpherson & Co. Ltd.)

Mr. C. H. Slade
(The British Domolac Co. Ltd.)

Mr. H. F. L. Turner
(Chas. Turner & Son Ltd.)

Mr. F. A. Bignell was re-appointed Honorary Treasurer, and Messrs. Lithgow, Nelson & Company were re-appointed Auditors.

AWARDS FOR ESSAYS ON CORROSION

S.C.I. Corrosion Group Competition

THE Education Panel of the Corrosion Group, has announced a competition designed to encourage those who are still in the early stages of their career to take an interest in corrosion science and to express their ideas in writing.

With the support of industrialists interested in the application of corrosion science in industry, it is proposed to offer a prize of 25 guineas, to be awarded annually, for an essay or paper on any aspect of corrosion of metals and its prevention.

Essays are invited from persons under 27 years on the closing date; a length about 3,000 words is suggested.

Judgement of the entries by a specially appointed panel will be based on arrangement of material, technical and literary excellence, and the evidence shown of the candidate's critical faculty and originality of thought. It is not necessary that the results of original research should be incorporated; entries may include, for example, surveys of knowledge in a particular field, discussion of practical

problems, and suggestions for future developments in research, in application of knowledge, or in organization of corrosion-preventive measures. The prize may be withheld, if, in the opinion of the judges, no entry of sufficient merit has been received.

Any candidate may subsequently be invited to deliver his or her contribution as a lecture.

Publication of any entry will rest with the Society of Chemical Industry subject to the regulations of the Society.

Entries should preferably be typed (double spaced), and must be on one side of the paper only with adequate margins. The candidate's name must not appear on the script and the entry must be enclosed in a sealed envelope bearing a pen-name. A second sealed envelope also bearing the pen-name and enclosing a statement of the full name, address and date of birth of the author must accompany the entry. The second envelope will be opened in the presence of the Committee of the Education Panel when the judges make their reports. Illustrations (diagrams and/or photographs) may be included with the entry, but must not provide means of identifying the author.

The closing date for receipt of entries is 31st March, 1956 and they should be addressed to:—

Corrosion Group Essay Competition
c/o Society of Chemical Industry,
56 Victoria Street, London, S.W.1.



TECHNICAL AND INDUSTRIAL APPOINTMENTS

Dr. G. L. J. Bailey B.Sc.(Hons.) Ph.D., has been appointed superintendent of the platinum metals research laboratory in the development and research department of **The Mond Nickel Co. Ltd.**, at Acton, London, in succession to Dr. E. C. Rhodes. He will take up his new appointment on February 1, 1956.

After taking his Ph.D. at London University in 1939 Dr. Bailey joined the staff of the Admiralty Engineering Laboratory and in 1945 went to the British Non-Ferrous Metals Research Association, where he is deputy research manager.

Mr. S. J. Reason has been appointed technical sales representative for **Nordac Ltd.** for the North of England.

The Oscar Hommel Memorial Scholarship in Ceramics will continue in 1955 for Ronald Stark, the award winner last year.

Mr. Stark was awarded last year's Hommel Scholarship by The Pennsylvania State University due to his outstanding scholastic record in high school. This year's \$300.00 scholarship in Ceramic Technology will help to further Mr. Stark's studies in his sophomore year at Penn State.

Mr. C. N. Taylor, London sales representative of **British Titan Products Co., Ltd.**, has been awarded a Travelling Scholarship to Canada and U.S.A., by the English Speaking Union.

The Scholarship is awarded to graduates of an English university who have a proven interest in Transatlantic friendship and trade.

It covers a four week visit to Canada and a two week visit to America.

Dr. Wilfred F. Coxon, who recently resigned as Editorial Director and Joint Managing Director of Arrow Press, Ltd., is developing and expanding his practise as an independent consultant on technical publicity problems from his office at 152, Fleet Street, E.C.4—Telephone, Fleet Street 1869.



Long Service Awards for George Kent Workers

An unusual number of long-service certificates were presented by Commander Philip W. Kent, R.N., Chairman of George Kent Ltd., at the annual ceremony at the Luton Works on November 18. Four members received the award for 50 years' service and 28 the certificate marking the completion of 25 years. The award for 50 years consists, traditionally, of an endorsement on the long-service certificate and a cheque for £25.

The photograph shows Commander Kent presenting his certificate to Mr. Harry Bailey, with, left to right, Mr. John Galashan, Mr. Sidney R. Quartermaine, and Mr. George Worker, all with 50 years' service.

Commander Kent, who was supported by other directors, remarked on the really wonderful total of years of service and working together that these annual ceremonies now represented. Since the inauguration of the certificates in 1935, and including the latest presentation, 538 of the certificates have been presented, and 22 have been endorsed for 50 years' service.

Mr. E. J. Bradbury, M.Eng., has been appointed assistant superintendent of the development and research department laboratory of **The Mond Nickel Co. Ltd.**, Birmingham.

He joined the Mond Nickel Co. Ltd., in 1941 but at the end of the year joined the Royal Air Force. On leaving the forces in 1946 he returned to the London branch as development officer where he was responsible for non-ferrous wrought alloys.

Mr. G. R. Blakely, B.Sc.(Eng.), M.I.C.E., M.I.Mech.E., M.I.Prod.E., has been appointed to the board of directors as works director of **G. A. Harvey and Co. (London) Ltd.** He joined the company in 1952 as general works manager.

Mr. A. Raymond Key has been appointed vice-president of **Johnson Matthey and Co., Inc.**, the American associate of Johnson, Matthey and Co., Ltd.

He joined the Birmingham branch of the parent company in April, 1935,

and remained there until the war when he left to join the Army. In June, 1946, he returned to Birmingham having attained the rank of Major.

He moved to the company's head office in Hatton Garden in January, 1952, and later in the year made an extensive tour of the U.S.A. He was transferred to the staff of Johnson, Matthey and Co., Inc. in April, 1953.

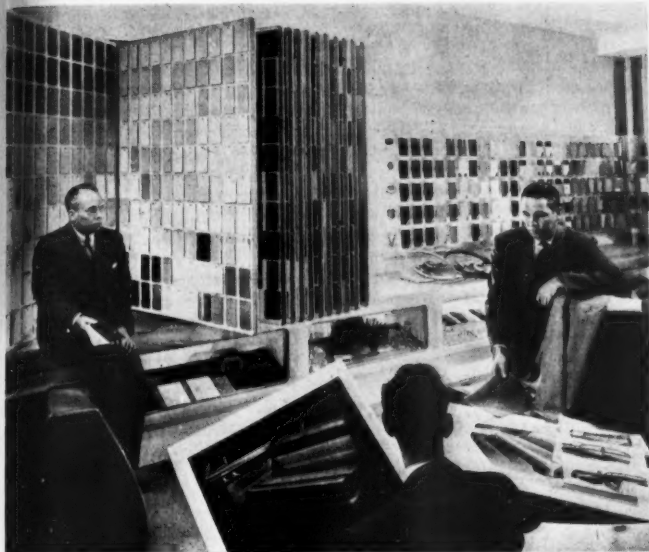
CHANGE OF ADDRESSES

The new address of **Dallow Lambert and Co. Ltd.**, is now Thurmarston, Leicester. Telephone: Syston 86931.

The address of the new **General Electric Co. Ltd.** depot in North Lancashire is Magnet House, Derby Street, Preston. Telephone: Preston 57871/2. The depot will be under the management of Mr. R. G. Galloway.

British Titan Products Co. Ltd. has announced that their new London Office address is now: The Adelphi, John Adam Street, London, W.C.2. Telephone: Trafalgar 4451.

COLOUR LIBRARY ASSISTS SELECTION OF AUTOMOBILE FINISHES



THE present-day trend in the colour of car finishes, particularly in the U.S.A. and increasingly in this country, is away from the traditional and ubiquitous black. The modern buyer may have a choice among 12 to 20 colours.

The famous "colour studio" of General Motors, in Detroit, U.S.A., has a "library" of approximately 4,750 colours and shades that have been tested and proved usable. Each year selections are made to adorn cars of the current vintage.

Against the overall, the cost of paint on a car is not a large item. The builders of cars, however, know that paint quality and effective application are important. The appearance and durability of car finishes have a high customer impact.

That is why development on car finishes has kept apace of the engineering and research activities, so that the actual elapsed time, from bare metal through several treatments, a primer coat, secondary coat and finishing coat today rarely exceeds three hours as against almost as many days twenty years ago.

General Motors, using a large quantity of auto paint each year, from the kind that is purely protective to the one that must beautify as well as protect, give the matter a lot of attention. They are continually seek-

ing improvements. The 4,750 colour chip panels, hanging in the colour studio in Detroit, are evidence of the result. No colour is admitted to the "library" until it has undergone rigorous laboratory and outdoor weather testing. At Miami, Florida, General Motors have an outdoor colour test field where thousands of painted metal chips, along with sample parts taken from production lines, are exposed to the weather. Measurements are made of the amount and intensity of sunshine, reaction to salt air, the total number of hours each piece is wet with dew, and the hours each is wet by rain. The staff also keep, for checking, a continuous record of rainfall, temperature and humidity. Type and amount of failure of paints which may occur under identical circumstances thus is determined within



very narrow limits.

There are other tests, however, which an approved auto paint must pass. In northern areas, where snow and ice are to be expected, finishes must be able to combat the corrosive action of salt, sand spray and tire-thrown stones.

In the General Motors Research Laboratories, there is a testing room where finishes are subjected to the action of salt for weeks at a time. A fine mist of salt solution is sprayed at intervals on the colour panel under test. A similar room is kept at 100°F. and 100 per cent relative humidity for judging the same paint. In still another room they are cooled to the temperature of zero, then removed and bent sharply, to gauge the endurance of the paint under the severe condition.

Stones thrown by tires not only pound the under surface of the car which may pick them up, but also strike other cars. The laboratory has a device which it has named the "Gravelometer" which spends its time throwing gravel at paint panels being tested. Results of all such tests are judged not only by eye appearance but by fine instrumentation.

S.C.I. ANNUAL MEETING

Plans for 1956

ACHIEVEMENTS of Industrial Chemistry" is to be the theme of the 75th Annual Meeting of the Society of Chemical Industry in London next year.

The nature of the lectures will be such as to enable speakers to review the major advances brought about by the work of industrial chemists in the last 25 years, and to look forward over the next 25 years to the centenary of the Society.

After a general introduction, there will be two parallel series of lectures, each of four. One series will deal with the products of industrial chemistry, the new processes which have been evolved and perfected, and the advances in fundamental science which made them possible. The other series will survey the tools of industrial chemistry today, and cover such subjects as modern manufacturing techniques and the use of metals and non-metals in plant construction.



New Company

Sutton Silica Co. Ltd., Sutton Street, Newcastle, Staffs. was registered as a private company on Oct. 5th, 1955, to carry on business as millers of Quartz and Silica for the Vitreous Enamel, Polishing and Abrasive Industries. Share Capital £15,000 in £1 Shares. Directors: W. Ralph Lawton and G. A. Barker.

Change of Name

The name of Wallis and Co (Long Eaton) Ltd. has been changed to **Leisure Kitchen Equipment Ltd.** The address remains the same.

OBITUARY

Gracie: Mr. W. F. Gracie a former director of Metal Heat Treatment Ltd., Sheffield died last month.

Simeon: Vice-Admiral Sir C. Simeon, who joined the board of Vickers-Armstrongs Ltd., after his retirement from the Royal Navy in 1946, died at the age of 65. He retired from Vickers-Armstrongs last year on reaching the age limit.



TECHNICAL BOOKSHELF



Transactions of the Institute of Metal Finishing—Fourth International Conference. Vol. XXXI. Published by The Institute of Metal Finishing, 32, Great Ormond Street, London, W.C.1. Price to Non-Members £3 10s. 0d.

It is a matter of great difficulty to review adequately a volume of annual proceedings, particularly one such as this, which covers the papers presented at a large International meeting and at which the authors were representative of some fourteen nations. Inevitably there must be considerable variation in the quality and technical interest in the thirty-two papers which comprise the volume, yet it would be invidious to select individual contributions for special mention, either as exceptionally good or disappointingly inferior examples.

In the main the volume contains a number of contributions of very high standard indeed, and even those which fall farthest short of the highest standard set, are not in themselves unworthy.

The subjects dealt with range widely from fundamental treatises on electrochemistry and crystal morphology to eminently practical discourses on cleaning cycles and bright nickel plating. Nor was electrodeposition the only technology covered, as both anodic processes and organic finishing also find their place.

It is noted in the brief description of the Conference, which serves as an introduction to the technical papers, that the Conference was attended by five hundred and nine delegates—a not insignificant proportion of the major metal-finishing interests in the Western Hemisphere. To all of these the book will certainly constitute a valued record of what was undoubtedly a memorable occasion. To those who were not present, the chief merit of the volume is that it affords not so much a work of reference on modern finishing techniques as a most interesting and informative compendium, from which much may be learnt concerning progress in metal finishing in countries other than our own.

Undoubtedly there is something for everyone in this volume, and it can most certainly be expected that references to the papers contained therein will be featured many times in bibliographies over the next few years.



Assembly-Line Layout Boosts Galvanizing Production

METAL parts move by overhead conveyor through pickle and rinse tanks before being galvanized at the new plant, at Jackson, Mich., U.S.A. of Quick Industries (see left).

The improved conveying methods and the modern production line layout were developed by the company in conjunction with the Hanson-Van Winkle-Munning Co., Matawan, N.J.

Sheet assemblies, pipe coils, pole line hardware and water tanks are galvanized at rates of 2500-3000 lb. per hr., twice the former output. In addition, the company report that they are now preparing and pickling parts more effectively and obtaining brighter zinc coatings as a result of improved processing.

Work is carried by electrically operated hoists on a monorail through a sulphuric-acid pickling bath, double-rinse bath, flux wash and galvanizing dip.

IMPROVED FACILITIES FOR POLAROGRAPHIC RESEARCH

Opening of New Laboratory in Cambridge

THE growing demand for the services of specialists in the various fields of science and technology today, together with the present acute shortage of trained and experienced scientists, is creating a problem of considerable magnitude in the realm of chemistry, where in spite of the development of physico-chemical analytical instruments as time-saving aids in the laboratory and on the plant, there is still an unsatisfied demand for chemists skilled in the operation of these instruments and in the interpretation of data.

This is no less true in the highly specialized field of polarography where the present shortage of semi-skilled and skilled polarographers is preventing the benefits of this technique from being freely available to science and industry. In some countries this shortage of polarographers has been met by the formation of groups of experts whose services to science and industry are available thus to ensure that the benefits arising from the use of this technique are available to all.

The earliest example of this type of specialist organization was the Central Polarographic Institute of Czechoslovakia established in Prague by Professor J. Heyrovsky, who invented the polarograph in 1925. This Institute is noted for its pioneering work in developing the theory of polarography and applying this knowledge generally to the problems of medicine and science. A most outstanding contribution which has received world-wide acclaim was the development by Brdicka in 1936 of the polarographic test for the diagnosis of cancer, known as the Prague Cancer Reaction. The application of the polarograph in serological cancer diagnosis was followed up by similar groups of polarographers in Spain, Germany and Russia. A central Institute for the study of Polarography has been set up at Padova in Italy under Semerano; other groups of polarographers are established in Denmark, Sweden, India and Japan, and a great deal of work of importance in the metallurgical and engineering fields has been carried out. Thus a number of countries throughout the world have established their groups of experts in this field, and have made valuable contributions to scientific investigations and to analytical chemistry.

Research in Great Britain

In Great Britain no exclusive outstanding experimental and development organization has been created, although many small units have been doing valuable work in this field. The Cambridge Instrument Co. Ltd., was one of the first, if not the very first, makers of polarographs in this country, the earliest instruments being sent out just before the Second World War. Dr. G. Jessop of the Research Department of the company has done a large amount of work on the development of polarographic instruments and techniques. Further, the Research Department has always endeavoured to help users of polarographs in the solution of their own particular problems. The volume of such work has so increased that it has not been possible, without delaying more fundamental research, to give the immediate service which is very desirable with such problems.

To remove this difficulty and to enable the company to develop its polarographic equipment more rapidly, a special Polarographic Research Laboratory was recently opened by Professor J. Heyrovsky and will be in the charge of Mr. W. J. Parker, B.Sc., A.R.I.C., A.M.Inst.F. The opening ceremony, under the chairmanship of Sir J. A. N. Barlow, Bt., G.C.B., K.B.E., was attended by a representative gathering from the academic, research and industrial fields. This laboratory, which will be employed exclusively on polarographic problems and development, is adjacent to the company's Cambridge works and the work carried on there will be carefully co-ordinated with the programme of work which will continue in the main Research Department. The specialized services of the laboratory will be available for advice and help to firms and to research workers interested in this subject, and it will be fully equipped for the demonstration of polarographic instruments and techniques.



Flame Spraying of NICKEL-MAGNESIA CERMETS

DURING the past several years, considerable experimental work has been conducted with nickel-magnesium oxide cermets as high-temperature protective coatings and also with the flame spraying of these cermets onto metal and alloys.

The present procedure is the outcome of an integrated experimental programme that has been carried out with alloy and super-alloy metals in the research laboratory of the O. Hommel Company, Pittsburgh, Pa., U.S.A. This has involved the use of special research facilities and the development of methods that have resulted in overcoming some of the inherent difficulties of successful application of these coatings.

The term "cermet" is used to define mixtures of ceramic refractory oxides, carbides, or borides with metal. The resulting materials have some of the properties of each of the components. Those cermet coatings showing the most promise are very refractory, with a high order of high-temperature corrosion resistance and usually also a good thermal shock resistance. They are neither as brittle as ceramics nor as ductile as metals, and they are far more resistant to corrosion than metals under most conditions.

The particular nickel-magnesium oxide cermet with which this work was concerned was developed at the Ohio State University Experiment Station. This cermet is a refractory material composed of magnesium oxide bonded with nickel metal. As a result of further research and development, flame-sprayed cermet coatings were discovered that have shown considerable promise in varied applications in the hot sections of military aircraft jet engines. More recently other uses have begun to appear for this type of coating where, for specialized purposes, the familiar ceramic coatings do not completely answer the needs.

To make these cermets, the necessary components are ground together in the dry state, pressed into pellets at a rather high pressure, and fired in the temperature range of 1370 to 1400°C. to form the cermet. After cooling,

(Continued on page 544)



Meetings of the Month

December 16

Institute of Metal Finishing (Sheffield and North-East Branch). "Selection of Protective Paints for Use in the Electroplating Industry," by H. A. Slade, B.Sc., A.R.I.C., at the Grand Hotel, Fitzwilliam Room, Sheffield, 6.30 p.m.

December 19

Institute of Metal Finishing (London Branch). "Tin - cadmium Alloy Plating," by A. E. Davies, B.Sc., Ph.D., A.R.C.S., D.I.C., at the Northampton Polytechnic, St. John Street, E.C.1. 6.15 p.m.

January 3

Institute of Metal Finishing (Midland Branch). "Zinc Plating" by D. N. Layton, Ph.D., M.Sc., A.R.C.S., D.I.C. A.Inst.P., at the James Watt Memorial Institute, Great Charles Street, Birmingham, 3. 6.30 p.m.

January 6

Junior Institution of Engineers. By permission of Dewrance and Co. Ltd., the following films will be shown:—"T.L.B. Metal Powder Deposition Process" and "Yarway Steam Traps" to be introduced by E. E. Bastick (member) at Pepys House, 14 Rochester Row, S.W.1. 7 p.m.

January 7

Institute of Metal Finishing (North-West Branch). Annual dinner and dance at the Cafe Royal, Peter Street, Manchester. 6 p.m.

January 10

Institute of Metal Finishing (Organic Finishing Group). "Performance Testing of Paint Films" by R. J. Brown and A. J. Birch, at the British Institute of Management, 8 Hill Street, W.1. 6.30 p.m.

January 13

Institute of Vitreous Enamellers (Midland Branch). Annual Dinner at the White Horse Restaurant, Birmingham.

January 16

Institute of Metal Finishing (London Branch). "The Effect of Metal Finishing Wastes on Sewage Purification" by A. E. J. Pettit, B.A., M.Inst.S.P. (Joint meeting with the Institute of Sewage Purification) at the Imperial College, South Kensington, 6.15 p.m.

January 19

Institute of Metal Finishing (Midland Branch). Annual Dinner and Dance

TRADE and TECHNICAL PUBLICATIONS

Rustproofing the Eiffel Tower: An account of an interesting trial on one of the world's best-known landmarks is contained in the October issue of *Jenolite News*—published by Jenolite Ltd., 13/17, Rathbone Street, W.1. Taking advantage of the fact that a new staircase was being installed on the West side of the Tower, the company offered to treat a number of the stair risers on the fifth flight. Slightly differing treatments were carried out on each of three sections of this flight involving in the first case the use of Jenolite RRN liquid, followed by Chemical sealer CS.1, in the second Jenolite RRN paste followed by RRN liquid followed by Chemical sealer, while the third set were treated under factory conditions by immersion in RRN solution at 70°C. The performance of these treated risers will be compared with that of the treads which have only received a coating of red lead.

High - speed Phosphate Treatment:

Walterisation Ltd., Purley Way, Croydon, have issued a leaflet describing the Walterisation 'E' process. This process was specially developed to meet the demand for a rapidly formed massive phosphate coating. With operating times of up to 10 min. the process is capable of producing a zinc-phosphate coating weighing up to 1.5 gm. per sq. ft. which makes it particularly suitable for use in automatic or semi-automatic conveyerized plant. The coating is satisfactory for subsequent sealing with a due and oil finish or with any suitable paint sequence.

"Magnesium for Cathodic Protection": Corrosion is responsible for the annual expenditure of enormous sums of money for the repair and replacement of underground and underwater steel structures.

The principle of cathodic protection, which has only recently been commercially developed, is an electrochemical method of preventing the corrosion of metals, in particular in underground and underwater structures of iron and steel.

Special types of magnesium alloy anodes have been developed to perform these operations completely

at the Grand Hotel, Colmore Row, Birmingham. 6.45 p.m.

January 26

Birmingham Metallurgical Society. "Electrolytic and Chemical Methods of Brightening" by H. Silman, B.Sc., A.M.I.Chem.E., F.R.I.C., F.I.M., at the Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2. 6.30 p.m.

satisfactorily. For example, underground pipelines can be guaranteed a corrosion-free life of 100 years.

Full information on the uses and applications of magnesium anodes is contained in this booklet available from Aluminium Union Ltd. Adelphi, W.C.2

Electrodeposition Abstracts: The October issue of the "Nickel Bulletin" published by the Mond Nickel Co. Ltd., Thames House, Millbank, S.W.1, contains an abstract on porosity testing of electrodeposited nickel coatings. The method described is one involving plating of nickel over an electrodeposit of radioactive iron on steel.

Also included in this issue is an abstract on the electropolishing of stainless steels where the polishing solution is based on a phosphoric-sulphuric acid mixture.

Nickel-Magnesia Cermets

(Continued from page 543)

the cermet is pulverized to the desired particle size for flame spraying. The necessary conditions to form this cermet satisfactorily seem to be: intimate mixing, bonding at high pressure to maintain this intimacy, and heating at high temperatures. Because the temperatures at which this cermet is formed are high, the raw ingredients cannot be fired directly on the alloy to obtain the same coating.

The flame spraying of powdered materials is a rather new technique. A fine cermet powder is forced through a high-temperature flame (usually oxyacetylene) that brings the individual particles to temperatures that ensure that the metallic portion of the material is molten, so that the particles will adhere to the surface being treated and also to each other. In practice, the surface of the article to be coated is prepared by sand blasting. The gun is used at a distance of 4 to 8 inches from the article, and the flame spraying is continued until the desired thickness of coating has been built up.

A flame sprayed nickel-magnesia cermet coating under oxidizing conditions is resistant to temperatures in excess of 1095°C., it has very excellent thermal shock resistance, and a frequent or repeated thermal gradient or shock of 1095°C. seemingly has no effect on the coating. It has a high insulating value also; and under the proper conditions, a coating of 15 to 20 mils has given as much as 372°C. differential in the temperature of the coated and uncoated sides of the alloy. This cermet coating is, however, not resistant to all atmospheres at high temperatures, and it is not the answer to all high-temperature corrosion problems.

Latest Developments in

PLANT, PROCESSES and EQUIPMENT

Highly Resistant Chemical Pumps

THE latest addition to the range of pumps manufactured by Worthington-Simpson, Ltd. of Newark, Notts., is a series of centrifugal chemical pumps having outstanding resistance to many acids, alkalis and slurries. The quality of the performance of these pumps can be gauged by the fact that they are capable of handling sulphuric acid in all strengths with a corrosion loss of not more than 0.005 in. per year when made in Worthite—one of the two alternative materials of construction.

The pumps are available in three different forms: Type DFC. Monobloc construction. (Fig 1). Pumps combined as one unit with totally enclosed, fan-cooled motors up to 1 B.H.P. in 3-phase type, 1½ B.H.P. in single-phase, and 2 B.H.P. in d.c., wound for standard voltage ranges.

Type DMC. Monobloc construction. Pumps combined as one unit with totally enclosed, fan-cooled 3-phase motors up to 17½ B.H.P. with windings specially impregnated with acid-resisting varnish. Stock motors are wound for 220/380, 400/440, 346/380 and 500/550 volts, but other voltages can be supplied. Of this type, single-phase capacitor motors up to 6 B.H.P. in standard ranges between 220/550 volts are also available. The rotors are of the squirrel-cage type and virtually indestructible.

Type D C. Pumps arranged for coupling to a special motor, engine, or belt drive—supplied with bare shaft, flexible coupling or complete motor drive on a baseplate.

The pumps in each case are available in either Worthite or 18/8/3 stainless steel. Worthite is a corrosion-resisting alloy steel which is greatly superior to the standard austenitic steel, particularly in pumping sulphuric acid. Containing more than 50 per cent

of the alloying elements, the carbon content is kept below 0.07 per cent to reduce to a minimum the tendency towards intergranular attack or inter-crystalline corrosion.

18/8/3 stainless steel is eminently suitable for mildly corrosive liquids. It is also advantageous where the liquid itself is non-corrosive, but no contamination or discoloration of the liquid is permissible—in many food or dyestuff processes, for instance.

The manufacturers will issue on request 1½-in. specimen discs of either Worthite or 18/8/3 for testing under site conditions.

An important feature of these pumps is that the pump casing remains the same whatever the seal used, and stuffing box packing or mechanical seals can be interchanged simply by the use of adapters to suit varying liquids. The mechanical seals can be supplied to suit either Worthite or 18/8/3 stainless steel pumps, and are designed so that the stationary and rotating faces are kept together positively and any wear is taken up automatically. The range covers a maximum output of up to 675 gal. per min. with heads up to 125 ft., depending on capacity. The maximum total suction lift at full capacities is—including all pipe and valve losses—15 ft. Up to 18 ft. suction lift can be obtained at lower capacities.

The range of liquids which these pumps can handle with very high resistance is very wide and includes glacial acetic acid, nitric acid at all concentrations at 70°F. and oleum up to 120°F.

The Monobloc construction brings the advantage of a single shaft linking motor and pump, thus ensuring perfect and maintained alignment, while the necessity of providing separate driving motors, baseplates, belts, pulleys, and couplings is entirely eliminated.

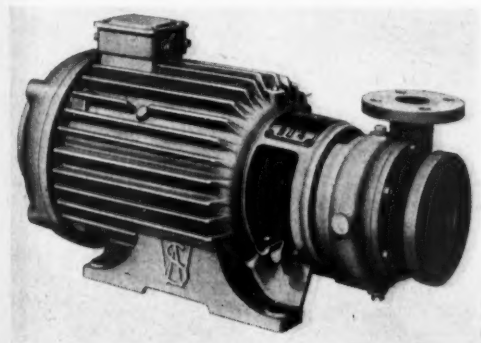
Colour Measuring Instrument

A NEW instrument for accurately measuring and comparing colours of papers, boards, paints and similar opaque materials, is now being tested at the laboratories of the Printing, Packaging and Allied Trades Research Association. The instrument which has been developed in consultation with Dr. V. G. W. Harrison of PATRA is being manufactured in this country and will be available to the trade shortly through the sole agents J. F. Crosfield Ltd., 2 Elthorne Road, London, N.19.

The device consists of two units—a measuring head and the main body containing power pack, electronic equipment and galvanometer. The measuring head consists of a light source maintained at a constant intensity level, a set of 12/18/24 narrow band interference filters and photo-electric cell.

Operation is simple. The instrument is plugged into

Fig. 1.—Monobloc chemical pump.



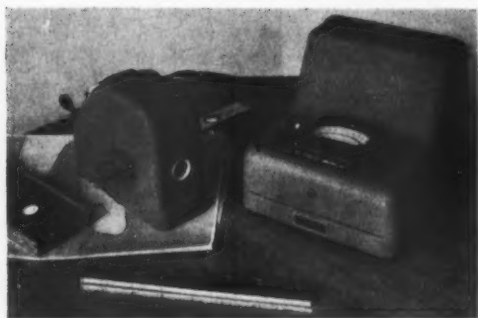


Fig. 2.—Colour measuring instrument.

the mains, allowed to warm up for 20 minutes and is then ready for use. As is the case in most colour measuring devices, it is necessary to obtain a 100 per cent reading before colour measurements can be made. This is achieved by positioning one of the filters and placing the measuring head on a standard white block of magnesium carbonate.

By adjusting one of the knobs on the body, the indicating needle is brought to the required position. The head is then placed on the test sample; electrical impulses are passed to the galvanometer and the reading obtained is the percentage reflection at the wavelength given by the filter. This procedure is repeated for each of the filters in turn and from the figures obtained a curve can be plotted. This curve gives a complete analysis of the colour under investigation.

Of attractive design, the instrument can be moved about quite freely provided the galvanometer is clamped beforehand. This can be done merely by depressing a switch.

The instrument, which has been under development for the past 18 months, is claimed to show considerable improvement over existing apparatus of the same type, but it is likely to cost more.

Pickling and Bright Dipping Cabinet

A NEW range of cabinets fabricated from PVC has been introduced by Plastic Constructions Ltd., 37, Weatheroak Road, Sparkhill, Birmingham, 11, for use in pickling and bright dipping operations.

These cabinets (Fig. 3) have been designed to give maximum service and efficiency based on an economical layout without any unnecessary fittings and the method of working is both simple and inexpensive. The design has been found satisfactory under working conditions and they are now being made in three sizes ranging from 5 ft long \times 2 ft. 9 in. wide \times 4 ft. high to 9 ft. long \times 3 ft. 6 in. wide \times 5 ft. 6 in. high.

The smallest size has a pickling tank 1 ft. 6 in. \times 1 ft. 6 in. \times 1 ft. 6 in. and a water swill. The largest has three pickling tanks 1 ft. 6 in. \times 1 ft. 6 in. \times 2 ft. and a water swill. The fumes are completely removed, washed and neutralised.

Rigid P.V.C. has been used throughout to give protection from corrosion without ageing.

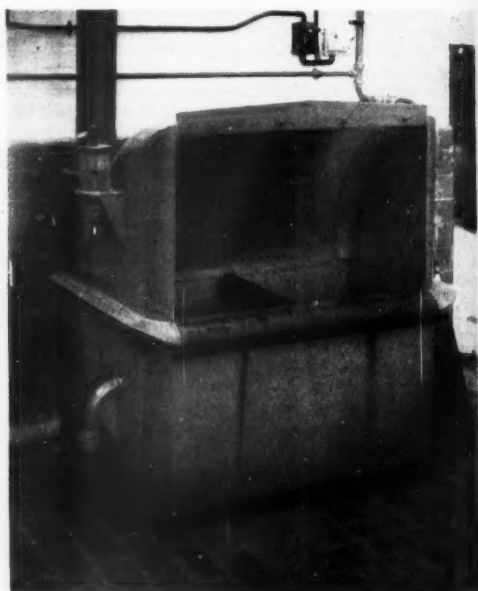
Chromic Mist Prevention

AS is well known, the large volume of gases liberated as bubbles during chromium plating, as a result of the high current densities used, results in the production of a considerable amount of chromic acid spray and mist which is both corrosive and toxic, and which may also adversely affect other plating processes in the vicinity.

In order to prevent the dissipation of this acid mist to the workshop atmosphere an exhaust ventilation system is necessary to remove the mist as it is formed, and the quantity of air exhausted for this purpose can be quite large. For example, to carry away the mist formed in a 2,000-gallon tank installation an exhaust rate of as much as 10,000 cubic feet per minute may be required, with consequent heavy costs both in capital installation and in the power consumption of the electric motors. Furthermore, even with the most efficient ventilating systems it is not always possible to obviate the mist formation completely, particularly with wide tanks and where there are strong draughts. There is also always a strong corrosion problem in the ducts of the ventilating system which become coated with condensed corrosive salts. Furthermore, since the loss of chromic acid through mist and spray can amount to as much as 30 per cent of the total acid used, a considerable additional expense is involved as well as a health hazard.

For all these reasons it is a significant announcement that a new surface-active fluorinated hydrocarbon which is now available has the property of creating a thin safe foam blanket during operation which completely stops the evolution of chromic

Fig. 3.—Plastic pickling cabinet.



gray. The product marketed under the name of Zeromist by the Electro-Chemical Engineering Co. Ltd., Netherby, Queens Road, Weybridge, Surrey, comes in the form of tablets and its use is claimed to reduce greatly the drag-out of chromium solution on plating racks as well as to eliminate almost completely the toxic and harmful chromium spray. It is not affected by the anode and cathode current densities normally used in decorative chromium plating (for deposits up to .001 inch). The initial quantity needed varies according to the operating temperature of the solution and lies between 1½ lb. and 3 lb. for each 100 gallons of chromium solution. Because of its extreme stability and the fact that it is lost from chromium plating solutions solely as a result of drag-out, the rate of consumption of Zeromist once the initial addition has been made is remarkably low.

Obviously, by the reduction of chromic spray evolution important savings would be possible in both the capital and operating charges involved in the installation of a ventilation system which while still as yet required by the Factory Act could clearly be of smaller capacity. There is also a potential saving of fuel since there will not be the same loss of heated air, and expensive scrubbing apparatus can also be eliminated.

Self-Conforming Abrasive Wheel

A NEW development in the polishing field, the 'PG' wheel, manufactured by the Minnesota Mining and Manufacturing Co. Ltd., Adderley Park, Birmingham, 8, is formed of over 1,000 segments of cloth-backed 3M coated abrasive and is self-conforming. The manufacturers claim that it retains its shape throughout its working life and requires no "breaking in" or dressing. As the wheel wears so it exposes fresh grain. It will perform all the jobs formerly done by such methods as dressed wheels, sisal and polishing buffs, yet it also removes stock, if desired. (See Fig. 4.)

The wheel has a long life with a consequent increase in production and saving in cash. In a demonstration one wheel lasted for 35 hours compared with a maximum of 15 to 20 minutes for set-up wheels performing the same operation. In tests at different r.p.m. the lowest 'PG' wheel life was 13 hours. An important feature is the self-conforming profiling action for finishing contoured surfaces in one operation.

The wheel is available in the following sizes: diameters 14, 15, 16 in., widths 2 to 6 in., grits 150 to 320. Bushing can be supplied to fit any size drive-spindle.

Infra-Red Units

THE infra-red lamp finds successful application in a wide range of processing duties on production lines, but for many classes of work it is claimed that a more effective source of infra-red radiation is provided by the metal sheathed element manufactured by George Vokes (Engineering Division) Ltd., High Road, New Southgate, London, N.11.

Lamps as commonly used provide an individual point source of heat and emit a considerable amount of energy in the form of visible light, whereas the Vokes element provides a linear heat source wasting very little energy as light.



Fig. 4.—Self-Conforming Abrasive Wheel

The elements, when mounted in the specially designed trough-shaped reflectors form efficient and robust infra-red units. These are made in three sizes, 18 in., 24 in., and 36 in. long—sizes found by experience to be those most suitable for general applications and for building up into banks. The convenient sizes, and robust construction of the elements make the projector particularly suitable for use as a portable unit or where vibration is experienced.

The units are suitable for such general infra-red heating applications as paint stoving; print, gum and adhesive drying, moisture extraction and heating, for manipulating PVC sheeting and other special processes. High intensity units are available for special purposes.

Dust Collecting Units

EIGHTEEN different models of industrial vacuum cleaners are being manufactured by the Bivac Air Co. Ltd., Stockport, Cheshire.

The machines work on the principle of multiple fabric filter-sleeves stretched over internal springs and secured to a top spigot plate.

The air and dust drawn into the collector is first subjected to a swirling cyclonic action, the bulk of the heavier dust being deposited in the dust-bin and the finer dust particles being restrained on the surface of the multi-tubular filter, leaving the dust on the outside of the circular cloth, free to drop off.

This air flow is the reverse of the normal one where the air has to pass through from the inside of a number of circular bags, forming a tube of dust which is difficult to shake off. With the "Clear-flo" filter, it is claimed no shaker gear is fitted or required.

Classified Advertisements

Prepaid rates: FIFTEEN WORDS for 7s. 6d. (minimum charge) and 4d. per word thereafter, or 24s. per inch. Box number 2s. 6d., including postage of replies.

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

SITUATION VACANT

ELECTROCHEMIST required, with experience in the metal finishing industry, for liaison work with industry and for laboratory development work. Initial salary up to £1,000 p.a. Write: Secretary, **BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION**, 81-91, Euston Street, London, N.W.1.

FOR SALE

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WANTED—ONE HIP BATH

For devious purposes of their own, not unconnected with their Annual Dinner and Dance, which is to be held on January 19, 1956 at the Grand Hotel, Birmingham, the Committee of the Midland Branch of the Institute of Metal Finishing are seeking to obtain the temporary loan of a hip bath, finish and condition immaterial.

Anyone willing to assist with the provision of this item is asked to communicate with the Hon. Secretary, Mr. I. T. WATKINS, Westalite House, Bradford Street, Birmingham, 5, from whom tickets for the function are obtainable, price 35s.

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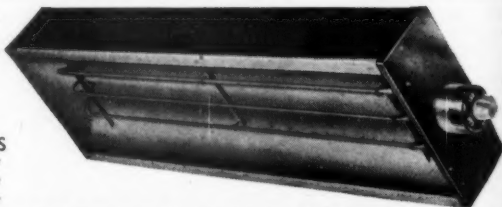
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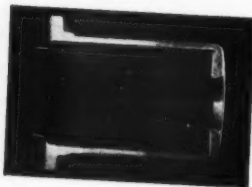
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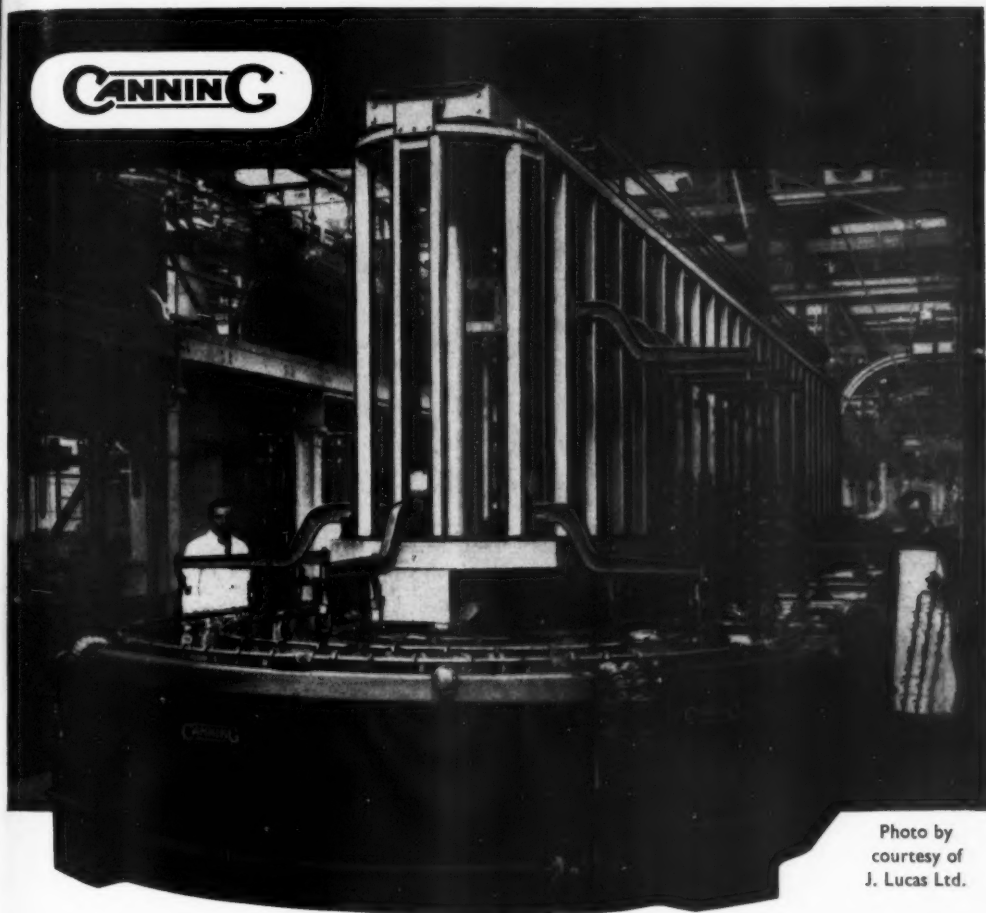


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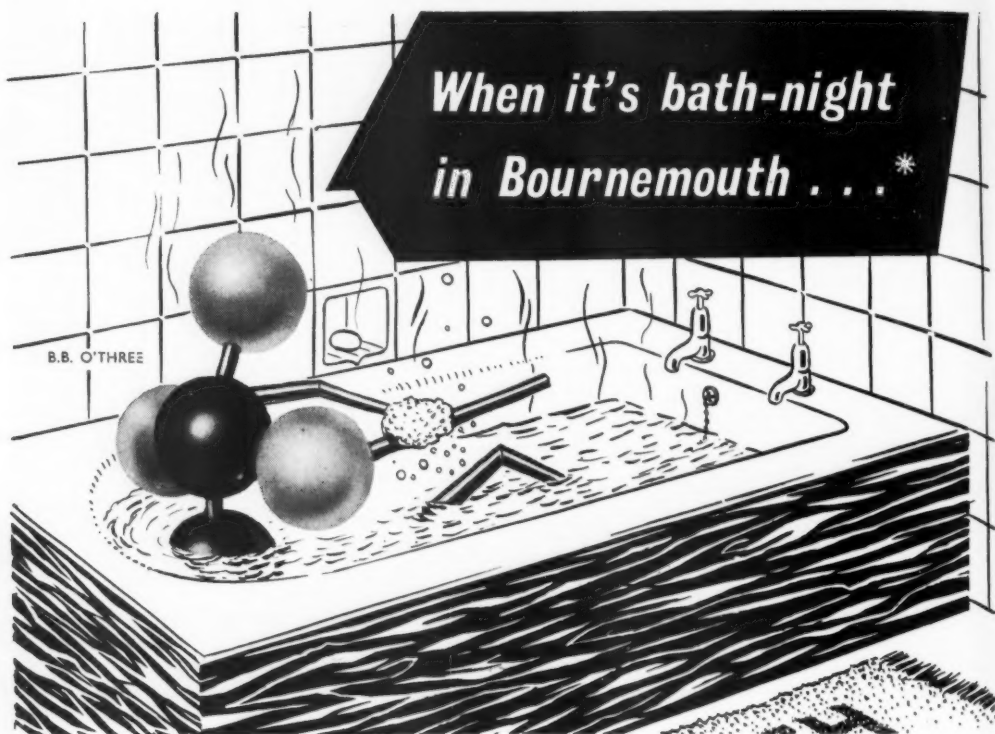
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Darlington	38.87	Preston	50.42
Exeter	33.02	Worcester	45.72
Leicester	45.85	York	39.36

(From the Crawford Survey, Part 2)

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